WATERSHED IMPLEMENTATION PLAN

BAYOU SERPENT WATERSHED

SUBSEGMENT 030701

Nonpoint Source Unit

EXECUTIVE SUMMARY

The Bayou Serpent watershed is located in southwest Louisiana, where it drains into the Calcasieu River. It is approximately 218 square miles in area and includes LDEQ Water Quality subsegment 030701. Most of the land is agricultural (over 75%) and forest land (about 12%). Approximately half of this agricultural land is pasture land and about 22% is rice-aquaculture. Less than 1% of the watershed is urbanized.

Bayou Serpent was included in the 2000 and 2002 305(b) Reports. It was found that the Bayou was not supporting its designated use of Fish and Wildlife Propagation because of low levels of dissolved oxygen. The Bayou was found to be fully supporting its other uses of Primary and Secondary Contact Recreation and Agriculture.

Bayou Serpent was also found to be in only partial support of fish and wildlife propagation due to the pesticide, Fipronil. This insecticide is used in rice farming to control the rice weevil and may also be toxic to crawfish. Fipronil is suspected as a causative agent in declining crawfish populations.

Bayou Serpent is used mostly as a conveyance for agricultural and storm water run-off as well as a source of irrigation water. It has been heavily dredged and has numerous weirs. The entire subsegment is extensively cultivated. Water quality in the Bayou Serpent watershed has been heavily impacted by agriculture.

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NPS IMPLEMENTATION PLAN FOR THE BAYOU SERPENT WATERSHED, SUBSEGMENT 030701 IN THE CALCASIEU RIVER BASIN

1.0 Introduction

Although Bayou Serpent, subsegment 030701, was not included on the court-ordered 303(d) list, it was included in the 2000 and 2002 305(b) Reports. As part of its ambient sampling monitoring program, LDEQ maintained a sampling station on the Bayou southeast of Hecker, Louisiana. Water quality data from this station were collected for the 12 months in 1999. It was found that the Bayou was "not supporting" its designated use of Fish and Wildlife Propagation, while fully supporting all other uses.

The LDEQ and the United States Environmental Protection Agency (USEPA) undertook modeling analyses for Bayou Serpent and developed TMDLs for organic enrichment/D.O. impairment and the pesticide, Fipronil. The LDEQ completed the TMDL for Bayou Serpent in 2001, after an intensive survey in July 2000. The TMDL addresses biochemical oxygen-demanding pollutants for the watershed.

The results of the TMDL summer projection model indicated that the water quality standard for dissolved oxygen of 5.0 mg/L can be maintained during the summer critical season with a 90 % reduction of nonpoint source pollution. This is not a realistic reduction goal and it may be that a more realistic summer standard is needed for Bayou Serpent. The results of the winter projection model indicated that the dissolved oxygen standard of 5.0 mg/L can be successfully maintained during the winter critical season with a 50% reduction in nonpoint source pollution.

1.1 Federal Authority

Section 319 of the Clean Water Act (PL 100-4, February 4, 1987) was enacted to specifically address problems attributed to nonpoint sources of pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Sec. 101; PL 100-4), which instructs the Governor of each State to prepare and submit a Nonpoint Source Management Program for reduction and control of pollution from nonpoint sources to navigable waters within the State by implementation of a four-year plan (submitted within 18 months of the day of enactment).

1.2 State Authority

In response to the federal law, the State of Louisiana passed Revised Statute 30:2011, signed by the Governor in 1987 as Act 272. Act 272 designated the Louisiana Department of Environmental Quality as the "Lead Agency" for development and implementation of the State's Nonpoint Source Management Plan. The Louisiana Revised Statutes R.S. 30:201.D (20) include the following provision as the authority for LDEQ to implement the State's NPS Program:

To develop and implement a non-point source management and ground water quality protection program and a conservation and management plan for estuaries, to receive federal funds for this purpose and provide matching state funds when required, and to comply with terms and conditions necessary to receive federal grants. The nonpoint source conservation and management plan, the groundwater protection plan, and the plan for estuaries shall be developed in coordination with, and with the concurrence of the appropriate state agencies, including but not limited to, the Department of Natural Resources, the Department of Wildlife and Fisheries, the Department of Agriculture and Forestry and the State Soil and Water Conservation Committee in those areas pertaining to their respective jurisdictions.

2.0 Description of Ecoregions

Bayou Serpent is located within the Calcasieu River Basin. The Calcasieu River Basin falls within three different ecoregions in Louisiana. The northern part of the Calcasieu River Basin is in the *South Central Plains* ecoregion, the hilly area. The central Calcasieu River Basin is in the *Western Gulf Coastal Plain* eco-region known as the "terrace", and the southern part of the Calcasieu Basin area is in the *Coastal Chenier Plain* eco-region, or "coastal marsh".

The *South Central Plains* is characterized by longleaf pine forests, high elevations, interior salt domes, hard sedimentary rock, excellent surface and groundwater resources, mature soils and the oldest rocks in the state. The soil types consist of coastal plain soils and flatwoods soils. Vegetation exists as longleaf pine forests and bottomland hardwoods.

The *Western Gulf Coastal Plain* has more moderate elevations on an older alluvium. The terrace region extends from the flatwoods to prairies. Flatwoods are low relief areas mixed with longleaf pine forest, pimple mounds,

Figure 1. Map of Louisiana Ecoregions

and flatwoods soils. Vegetation exists as flatwoods forest (longleaf pine, oak, palmetto, and tupelo), and bottomland hardwoods. Throughout the terrace region are strips/pockets of cypress forests.

The "coastal region" is characterized by very low relief. It has prairie grasslands, prairie soils, pimple mounds, ice-age channels, and small, shallow un-drained ponds. Slow moving rivers that are tidally influenced near the gulf coast are common in the *Coastal Chenier Plain*.

Features of the Bayou Serpent Watershed are predominately characteristic of the *Western Gulf Coastal Plain*. The land is mostly homogenous with flat prairies now dedicated to agriculture.

2.1 Historical Data for the Calcasieu Basin

Only one year of ambient data is available for the Bayou Serpent Watershed. Since it is difficult to establish trends based on such a small set of data, historical data from additional sites in the Calcasieu Basin have been analyzed and presented within this plan as additional information on water quality in the Calcasieu River Basin.

There are nine historic water quality network sites in the Calcasieu Basin, some of which have data from 1958. For comparison, sampling sites were split into three groups: Upper Calcasieu, Lower Calcasieu, and Tributaries. The Upper Calcasieu consists of sites 93, 95, 96, and 97, which are on the Calcasieu River upstream of the saltwater intrusion barrier. The Lower Calcasieu consists of sites 26 and 27, which are on the Calcasieu River downstream of the saltwater intrusion barrier. Sites 92, 94, and 131 are on the tributaries to the Calcasieu River and make up the Tributary group for analysis.

1.1.1 SITE NUMBER	1.1.2 SUBSEGMENT	1.1.3 DESCRIPTION	YEAR SAMPLING BEGAN	LAST YEAR SAMPLED
26	030304	Calcasieu River near Burton Landing, Louisiana	1971	2001
27	030301	Calcasieu River near Lake Charles, Louisiana	1971	1998
92	030801	Calcasieu River (West Fork) near Lake Charles, Louisiana	1971	1999
93	030201	Calcasieu River at Moss Bluff, Louisiana	1958	2001
94	030901	Bayou D'Inde near Lake Charles, Louisiana	1978	1998
95	030103	Calcasieu River near Kinder, Louisiana	1958	1999
96	030103	Calcasieu River northwest of Oberlin, Louisiana	1967	1998
97	030103	Calcasieu River near Oakdale, Louisiana	1958	1998
131	030702	English Bayou near Lake Charles, Louisiana	1984	1998

Table 1. Sampling Locations in Calcasieu Basin

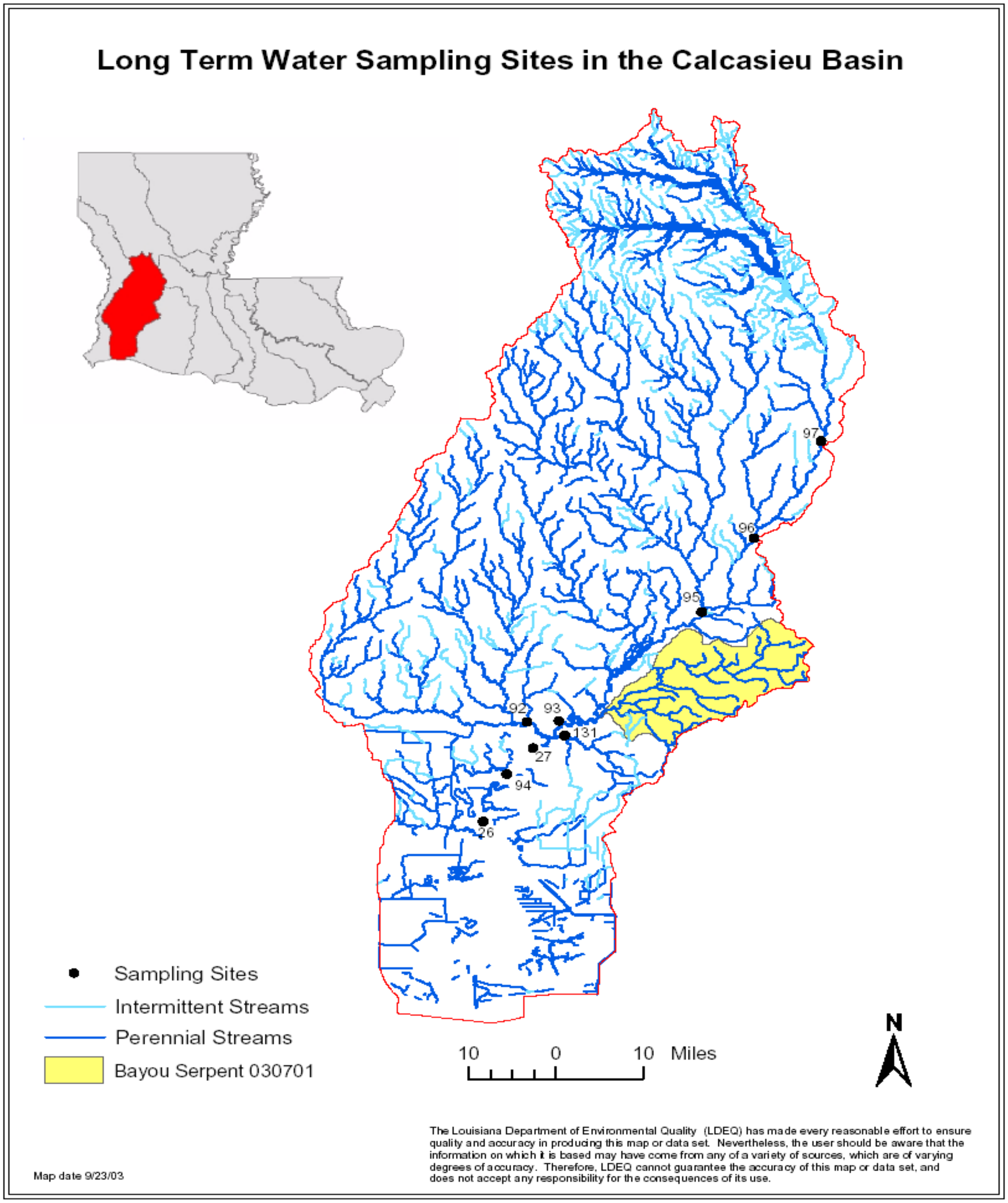


Figure 2. Long Term Water Sampling Sites in the Calcasieu Basin

The data from all sites and all years reveal some characteristic seasonal trends. From March to August dissolved oxygen values decline and appear to correspond to increasing water temperature. Overall, water quality seems a little better in the upper Calcasieu than in the lower Calcasieu and the tributaries. The median values by month for the lower Calcasieu and the tributaries drop below the 5 ppm dissolved oxygen standard, but the upper Calcasieu does not.

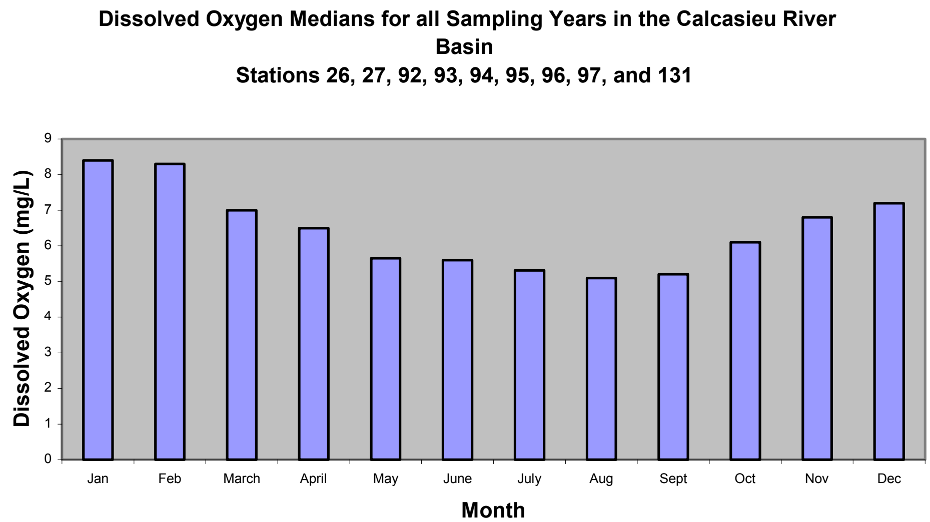


Figure 3

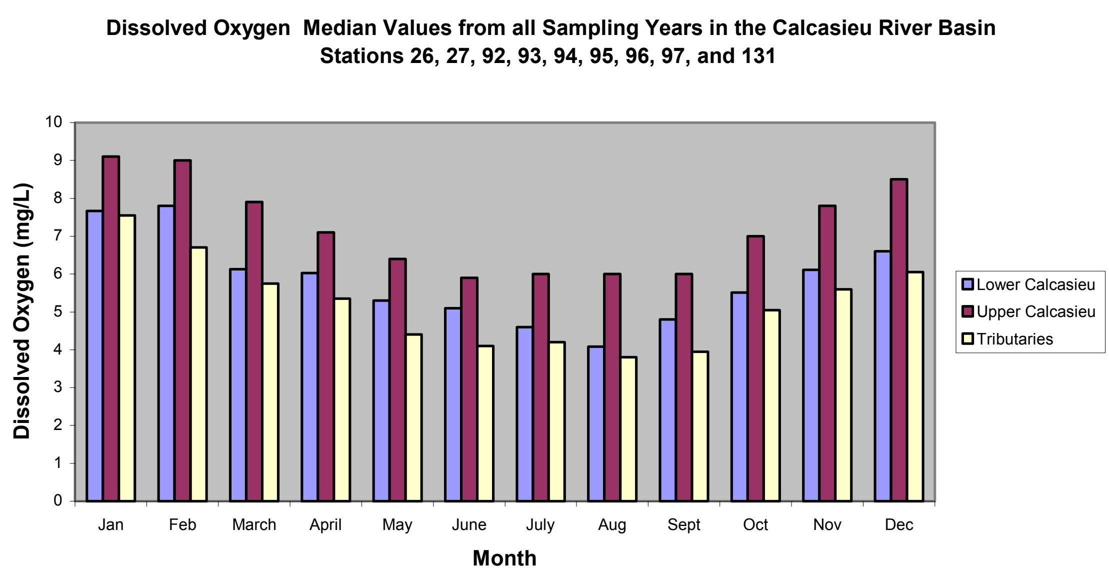


Figure 4

2.2 Bayou Serpent Watershed, Subsegment 030701

Bayou Serpent is located in southwestern Louisiana. It is a tributary to the Calcasieu River, which it joins about seven to eight miles north of Lake Charles. Bayou Serpent runs through the parishes of Allen (at its headwaters), Jefferson Davis and Calcasieu. The Bayou is subject to salt water encroachment in the lower reaches, near its confluence with the Calcasieu River. It is also affected by backwater flows from the Calcasieu. It has been heavily dredged and has little or no canopy over most of its length. Rice farming and cattle grazing are common land uses adjacent to the Bayou.

This TMDL model extended from the headwaters near Kinder, Louisiana to the confluence of Bayou Serpent with the Calcasieu River, northeast of Lake Charles. There were 29 stream reaches defined by the TMDL model. Stream reach 1 is at the northernmost part of Bayou Serpent, the headwaters at US 190. Stream reach 29 is at the south of Bayou Serpent, where it joins the Calcasieu River. Nine of the 29 reaches (Bayou Arceneaux, Cow Bayou, Bayou Alligator, Gum Bayou, and five unnamed tributaries) were modeled as distinct tributaries that drain into the main stem.

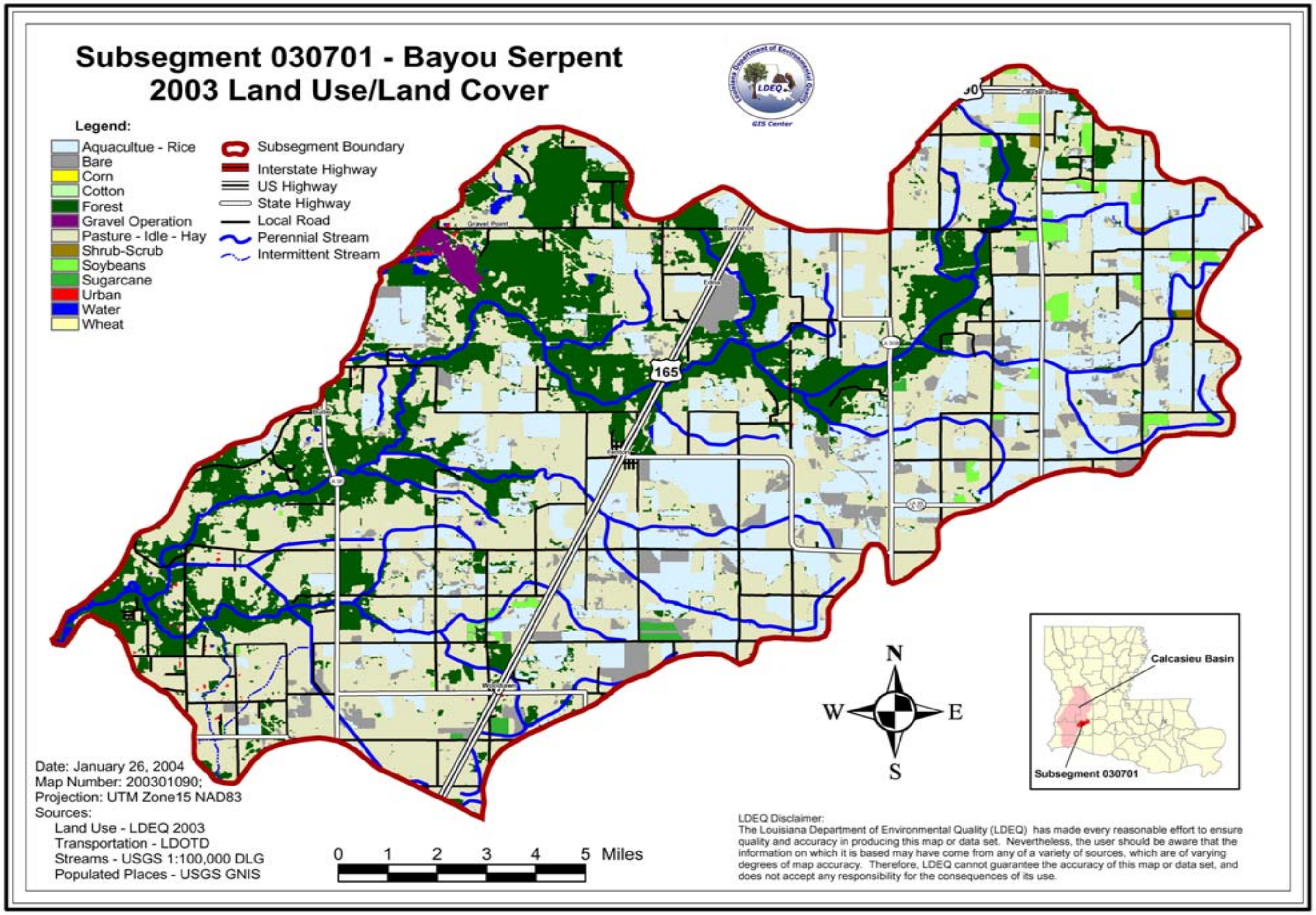


Figure 5. Digital Orthophoto Quarter Quadrangle map of Bayou Serpent Watershed

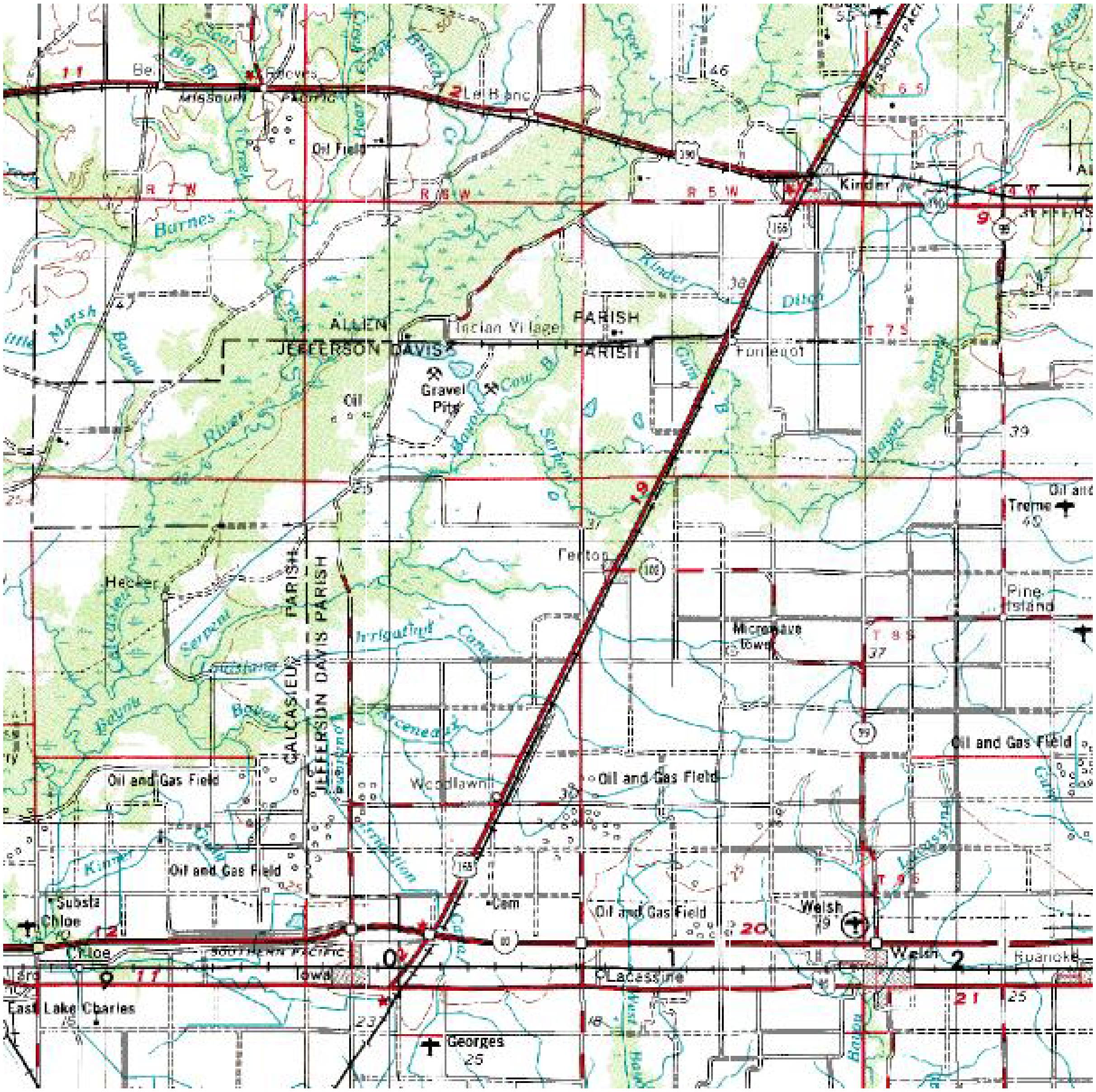


Figure 6. Bayou Serpent Watershed and surroundings

Designated uses specific to Bayou Serpent include primary contact recreation, secondary contact recreation, fish and wildlife propagation, and agriculture. Primary contact recreation (PCR) includes recreation such as swimming and water skiing. Secondary contact recreation (SCR) is recreation where body contact is incidental, such as fishing and boating. Propagation of Fish and Wildlife involves the protection of aquatic habitat, food, reproduction and travel corridors. Agriculture involves the use of water for crop spraying, irrigation, livestock watering, poultry operations, and other farm purposes not related to human consumption. Bayou Serpent was found to be "not supporting" its designated use of Fish and Wildlife Propagation.

Designated Use	Measured Parameter	Support Classification for Measured Parameter		
		Fully Supporting	Partially	Not Supporting
Primary Contact Recreation (PCR)	Fecal coliform[1]	0-25% do not meet criteria	-	>25% do not meet criteria
	Temperature	0-30% do not meet criteria	>30-75% do not meet criteria	>75% do not meet criteria
Secondary Contact Recreation (SCR)	Fecal coliform[1]	0-25% do not meet criteria	-	>25 % do not meet criteria
Fish and Wildlife Propagation (FWP)	Dissolved oxygen[2]	0-10% do not meet minimum of 3.0 ppm and median > criteria of 5.0 ppm	-	>10% do not meet minimum of 3.0 ppm or median < criteria of 5.0 ppm
	Dissolved oxygen[3]	0-10% do not meet criteria	>10-25% do not meet criteria	>25% do not meet criteria
	Temperature, pH, chloride, sulfate, TDS	0-30% do not meet criteria	>30-75% do not meet criteria	>75% do not meet criteria
Agriculture (AGR)	None	-	-	-

1. For most water bodies, criteria is as follows: PCR, 400 colonies/100 mL; SCR, 2,000 colonies/100 mL (see LAC 33:IX.1123).

2. Water bodies without a special study to establish specific criteria for D.O.

3. Water bodies for which a special study has been conducted to establish criteria for D.O.

Table 2. Fecal Coliform Standards

2.3 Watershed Land Uses

Land use in the Bayou Serpent Watershed is mostly agricultural, with rice, cattle and crawfish as the predominant types of farm operations. A combination of drought conditions and low commodity prices has resulted in the conversion of many existing rice farms to cattle grazing. Only a small percentage of the land has been urbanized.

LAND USE TYPE	NUMBER OF ACRES	% OF TOTAL AREA
Agricultural land	100,364.38	76.91
Barren Land	22.06	0.02
Forest land	16,237.03	12.44
Rangeland	4,993.05	3.83
Urban or built-up	938.86	0.72
Water	2,565.76	1.97
Wetland	5,380.10	4.12
TOTAL	130,501.24	100.00

Table 3. Land Use in the Bayou Serpent Watershed [From the TMDL, LDEQ (November, 2001)]

There is still much forested area (12.44%) in the Bayou Serpent Watershed. This is primarily along the main stem of the Bayou Serpent and its tributaries: Bayou Arceneaux, Little Bayou, Cow Bayou, and Gum Bayou. It is expected that water runoff, nutrient and sediment loads would be lowest from these forested areas.

The main urban areas in the Bayou Serpent watershed are Fenton, Woodlawn, Indian Village, Hecker, and Lauderdale. The largest of these is the Village of Fenton, which had 380 inhabitants in the 2000 census.

Soils within the Bayou Serpent Watershed are poorly drained to moderately well drained. The main stem of the Bayou Serpent is mostly floodplain. The surroundings are level to moderately sloping. A loam surface layer is underlain by a clayey and loamy subsoil throughout much of the watershed.

3.0 TMDL

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and assimilate while still meeting water quality standards. At the same time, it is also a measure of the total amount of pollutant that point sources are allowed to discharge into the waterbody. It determines the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and establishes the load reduction necessary to meet a given standard.

Subsegment	030701
Stream Description	Bayou Serpent – Headwaters to Calcasieu R.
Designated Uses	ABCF
Criteria:	
Chlorides	250 mg/L
SO_4	75 mg/L
D.O.	5 mg/L
pH	6.0-8.5
BAC	Note 1
TDS	300 mg/L

USES: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

Note 1 – Primary Contact Recreation: 200 colonies/100 mL maximum log mean and no more than 25% of samples exceeding 400 colonies/100mL for the period May through October; 1,000 colonies/100mL maximum log mean and no more than 25% of samples exceeding 2,000 colonies/100mL for the period November through April.

Table 4. Water Quality Numerical Criteria and Designated Uses for Bayou Serpent

TMDL findings are based upon critical conditions. For dissolved oxygen TMDLs, low flow and warm temperatures define the critical condition. The TMDL is calculated for flow conditions of 7Q10. 7Q10 is a low stream flow measure (seven days, 10-year average low flow). It refers to stream flow that occurs over seven consecutive days and has a 10-year recurrence interval. Daily stream-flows in the 7Q10 range are indicative of drought conditions and generally occur during the critical summer months. During low flow conditions, the impacts from pollutants may be magnified, as there is less water to dilute their effects. 7Q10 is a way to measure conservatively and may be thought of as a “worst-case-scenario”.

The TMDL is comprised of a waste load allocation (WLA), a load allocation (LA) and a margin of safety (MOS). The waste load allocation is the load allocated to point sources/discrete dischargers. The load allocation is the load allocated to nonpoint sources/runoff. The margin of safety is a percentage of the TMDL that acts as a buffer, accounting for the uncertainties associated with the model assumptions and data inadequacies.

The recommended water quality standard for dissolved oxygen in Bayou Serpent is 5.0 mg/L all year long. The TMDL survey was conducted under drought conditions and there is some uncertainty associated with the model's findings. The reality is that Bayou Serpent is used mostly as a conveyance for agricultural and storm water run-off as well as a source of irrigation water. It has been heavily dredged and has numerous weirs. The model indicates that the 5.0 mg/L D.O. criterion cannot be met under natural summer conditions.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers (Mississippi and Atchafalaya) and Lake Pontchartrain are sampled throughout the five-year cycle.

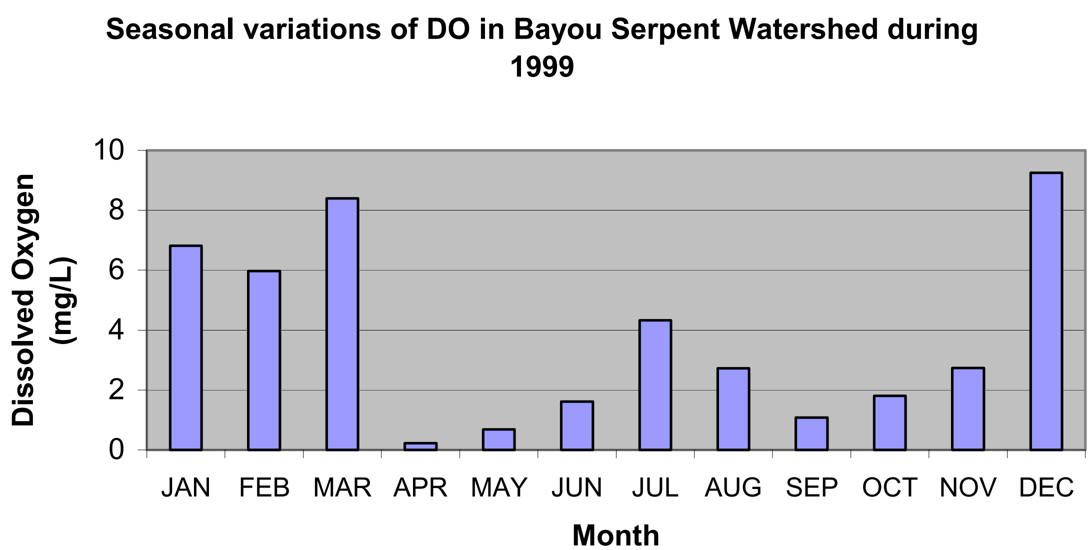


Figure 7

3.1 Nonpoint Source Loading in Bayou Serpent

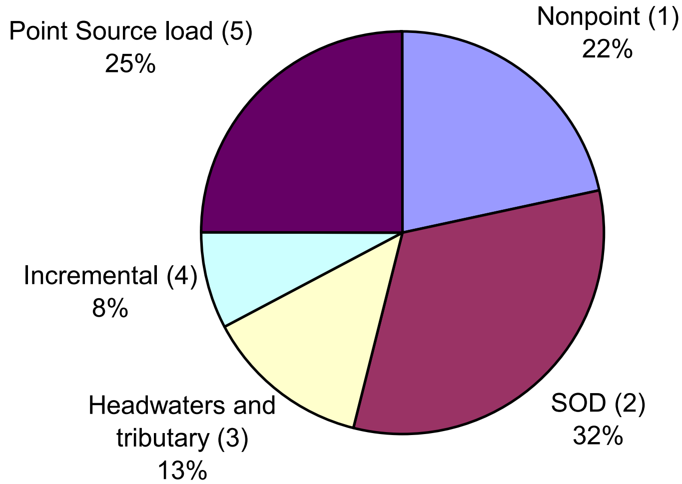
It has been estimated that 54 percent of the water pollution problems in Bayou Serpent may be related to nonpoint issues. This includes the 32 percent coming from sediment oxygen demand (SOD) or the benthic material. This benthic material contains oxygen demanding pollutants and is found in the streambed where, over time, it has become entrenched. It is difficult to maintain appropriate D.O. levels while this bottom layer exists. Bayou Serpent would benefit greatly from BMP implementation on agricultural lands.

Source	**kg/day**	**Percent of total load**
Nonpoint[1]	2187.25	22%
SOD[2]	3215.17	32%
Headwaters and tributaries[3]	1338.99	13%
Incremental[4]	773.73	8%
Point Source[5]	2518.25	25%
Total	10,033.39	100%

[1] Nonpoint load is the material running off the watershed into stream system.
[2] Sediment oxygen demand (SOD) is the benthic load that resides on the stream bottom.
[3] Headwaters and tributaries refer to the loading from tributaries and headwater.
[4] Incremental load includes ground water, rain events, and tributaries.
[5] Waste loads are the amount of pollutants discharged from industrial and municipal point sources in the waterway.

Table 5. Distribution of Load for Oxygen Demanding Substances in the Bayou Serpent

LOAD DISTRIBUTION



(1) Nonpoint load is the material running off the watershed into stream system.
(2) Sediment oxygen demand (SOD) is the benthic load that resides on the stream bottom.
(3) Headwaters and tributaries are the loadings from tributaries and headwater.
(4) Incremental load includes ground water, rain events, and tributaries.
(5) Waste loads are the amount of pollutants discharged from industrial and municipal point sources in the waterway.

Figure 8

The spikes seen on the graphics following (Figures 12 and 13) show an area of high BOD loading around River Kilometer 42.9. This corresponds to a tributary of Serpent designated Unnamed Tributary 2 in the TMDL model. This tributary is quite long and drains that area of most intense aquaculture-rice production in the Bayou Serpent Watershed. This area, northeast of Fenton, is sparsely populated and crisscrossed with parish roads, many of them unpaved.

The next largest nonpoint spike is seen at River Kilometer 36.2. This area is south of River Kilometer 42.9, but still northeast of Fenton. It would likely be subjected to many of the same pressures. The land use data do indicate more pasture and cattle grazing here.

Figure 9. Extensive Rice Fields Near River Kilometer 36.2. This unnamed tributary to the east of Bayou Serpent is receiving discharge from an incoming ditch. It appears to drain vast rice fields. Note the absence of a riparian buffer. This picture was taken in May 2003 from a local road west of LA 3086 and northeast of Fenton.

On the second graph, Figure 13, there is a pronounced spike seen in wastewater discharge at River Kilometer 20.2. In the TMDL model, River Kilometer 20.2 corresponds to Reach 26, a section of the main stem Bayou Serpent. (There were 29 reaches.) Three distinct tributaries feed into Reach 26. These tributaries have point sources discharging into them, one of these sources being the Village of Fenton. Although designated as wastewater discharges, the Village of Fenton and others were found to have no significant impact upon Bayou Serpent.

3.2 Tributaries

Bayou Alligator

Bayou Alligator juts off to the east of Serpent about three miles south of its intersection with US 190. It crosses LA Highway 99, just north of an oil and gas field. Bayou

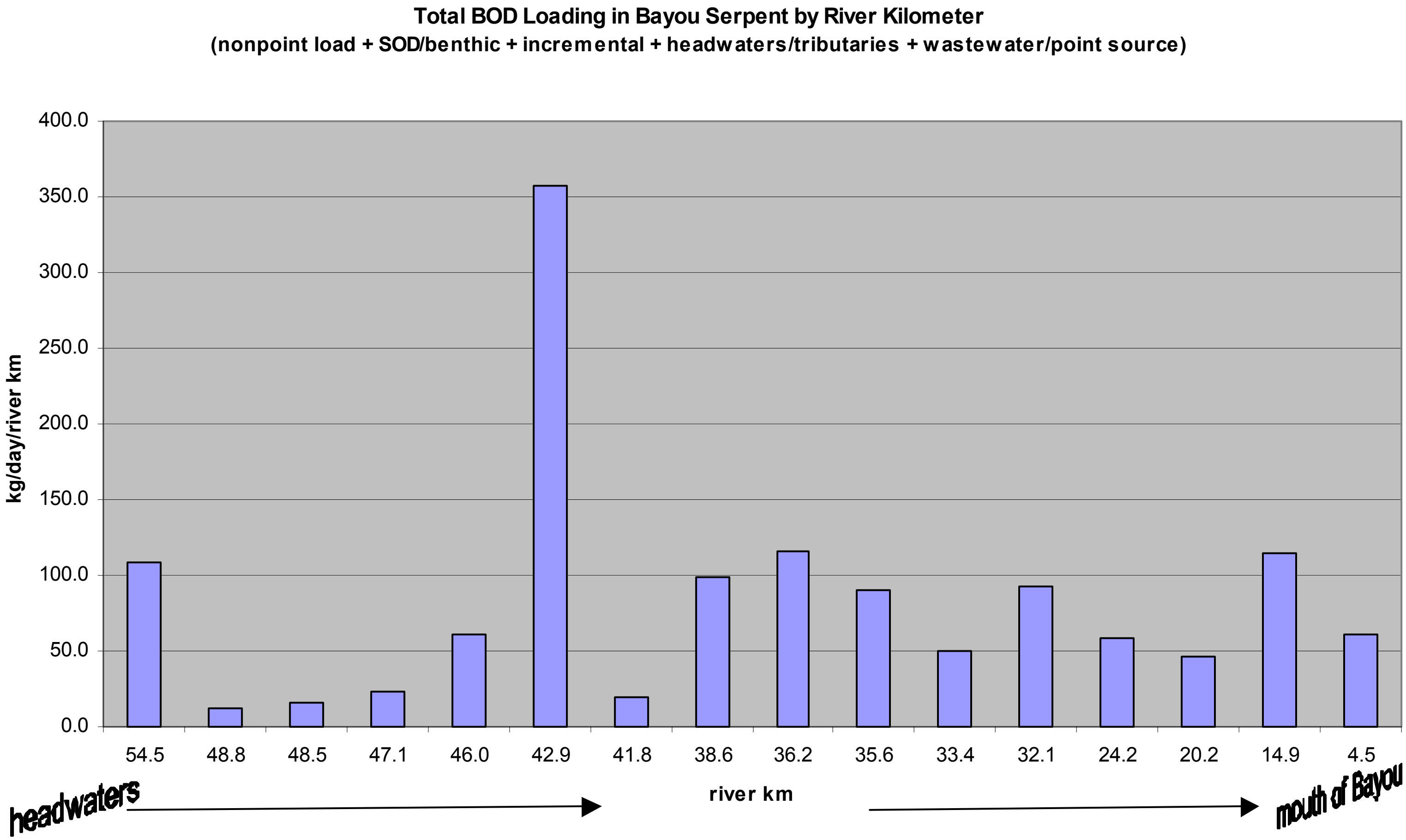

Total BOD Loading in Bayou Serpent by River Kilometer
(nonpoint load + SOD/benthic + incremental + headwaters/tributaries + wastewater/point source)
kg/day/river km
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
54.5
48.8
48.5
47.1
46.0
42.9
41.8
38.6
36.2
35.6
33.4
32.1
24.2
20.2
14.9
4.5
river km
headwaters
mouth of Bayou

Figure 12

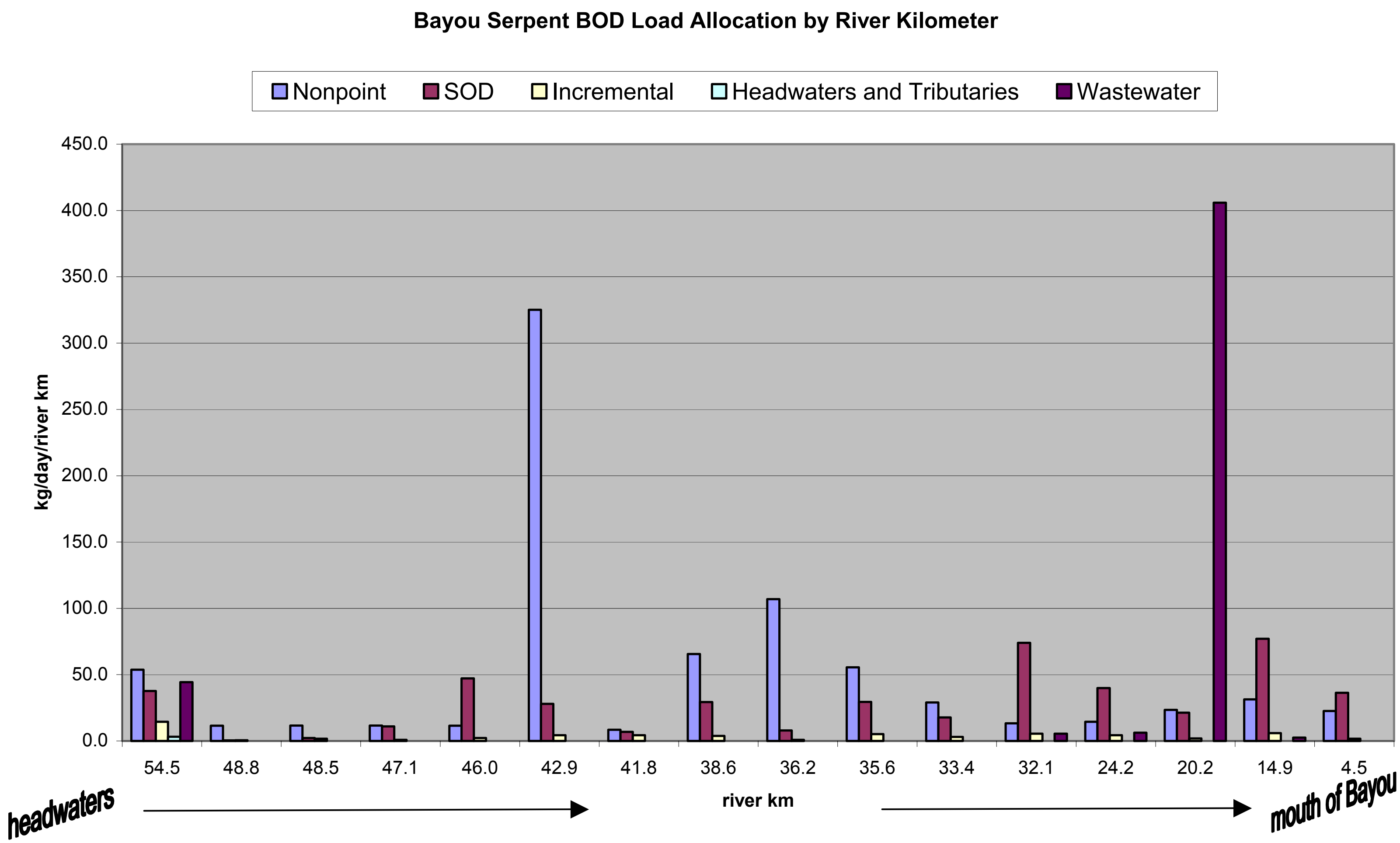

Bayou Serpent BOD Load Allocation by River Kilometer
Nonpoint
SOD
Incremental
Headwaters and Tributaries
Wastewater
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
kg/day/river km
54.5
48.8
48.5
47.1
46.0
42.9
41.8
38.6
36.2
35.6
33.4
32.1
24.2
20.2
14.9
4.5
headwaters
river km
mouth of Bayou

Figure 13

Alligator is very turbid and flowing. Several irrigation pumps operate and much of the flow in this Bayou may be driven by irrigation waters. Bayou Alligator drains extensive rice fields. There is some commercial pine forest near the confluence of Alligator with Bayou Serpent.

Figure 10. Bayou Alligator looking west (toward Serpent) at LA 99. There is some commercial pine in this area.

Figure 11. Bayou Alligator looking east at LA 99 Note the rice fields.

Gum Bayou

Gum Bayou flows to the north of Serpent, perpendicular to where Bayou Serpent has a mostly east-west alignment. Gum Bayou crosses US Highway 165, at the town of Edna.

Cow Bayou

Cow Bayou also flows to the north of Serpent, perpendicular to the main stem. It runs through an unpopulated area and is not immediately accessible on public roads. Cow Bayou, along with Thompson's Gully, is south of and adjacent to a large sand and gravel operation in Indian Village, Louisiana. The Bayou receives flow from canals that service Gravel Point.

Thompson's Gully

Thompson's Gully flows to the west of Serpent, south of the sand and gravel operations at Indian Village. As stated earlier, there is a large spike in wastewater discharge associated with this part of the watershed.

Little Bayou

Little Bayou flows to the east of Serpent, crossing US Highway 165 south of the town of Fenton. After crossing the highway, Little Bayou splits into several forks.
Little Bayou is small with some flow. It is highly turbid. At US Highway 165, Little Bayou appears to drain a vast expanse of rice fields interspersed with pasture. At least one weir is visible from the highway bridge. The land is dotted with some crawfish production.

The Village of Fenton discharges to an unnamed ditch which flows into Little Bayou before finally draining into Bayou Serpent. LDEQ ran an uncalibrated model for this receiving stream: the Unnamed Ditch to Little Bayou to Bayou Serpent. The model concluded that Fenton has no impact on either Little Bayou or Bayou Serpent.

Bayou Arceneaux

Bayou Arceneaux splits off from Serpent only about two miles from the confluence of Serpent with the Calcasieu River. Arceneaux flows to the east of Serpent for about six miles before it splits into two forks. These forks pass through oil and gas fields near the town of Woodlawn and eventually cross US Highway 165.

Bayou Arceneaux is highly turbid, with low to no flow. It supports healthy riparian vegetation and is surrounded by mixed pine forest. Rice fields surround the Bayou and it is possible that Arceneaux is a source of Fipronil impairment in Bayou Serpent.

4.0 AnnAGNPS Model Run

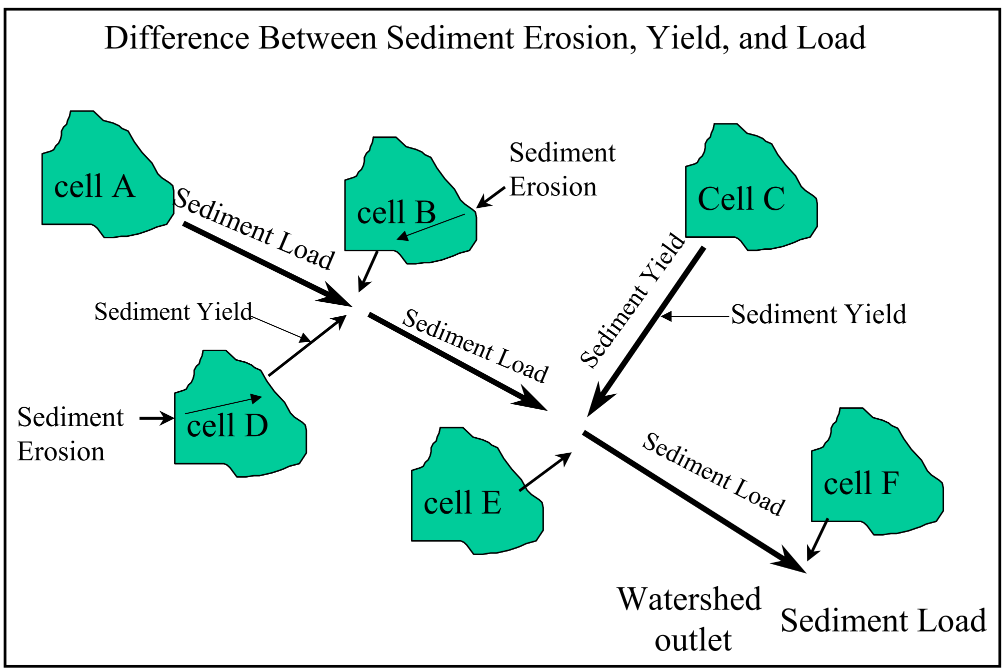


Figure 14. AnnAGNPS describes soil run-off in 3 basic categories: 1) Sediment Erosion is soils moving across the cells; 2) Sediment Yield is the soils of the cell depositing into the stream; 3) Sediment Load is the soil moving through the stream from reach to reach.

LDEQ is utilizing a model called **Ann**ualize **Ag**riculture **N**on-**P**oint-**S**ource (AnnAGNPS), a Natural Resources Conservation Service (NRCS) sponsored model, to evaluate current sediment loadings in the watershed. The model is used to evaluate the effectiveness of various BMPs and compare them to standard agricultural practices. The model produces estimates of the amounts of sediment, phosphorus, nitrogen, and organics as these constituents travel overland, through the reaches and out the watershed outlet. It is an extremely robust model having over 900 input parameters. Cells (land area representations) of a watershed are used to provide landscape spatial variability. Each cell homogeneously represents the landscape within its respective land area boundary. The physical and chemical constituents are routed from their origin within the land area and are either deposited within the stream channel system or transported out of the watershed. Pollutant loadings can then be identified at their source and tracked as they move through the watershed system.

AnnAGNPS is a multi-temporal, continuous-simulation model that was set up to simulate 30 years of local climate data. The model produces sediment loss by particle size class and source of erosion and divides the runoff into three categories: Sediment Erosion, Sediment Yield, and Sediment Load. Sediment Erosion is the amount of sediment that travels overland to the edge of the cell. Sediment Yield is the amount of sediment that is deposited into the stream network. Sediment Load is the amount of sediment that travels through the stream network and out the outlet. The results are presented in standard tons/acre/year.

Similarly, the model estimates runoff and loading for nitrogen, phosphorus, and organic carbon. The nutrient and organic results are presented in lbs/acre/yr. In addition, the model predicts how much water runs off a watershed cell.

Type of Model Results	Results	Units	Description
Sediment Erosion	0.690	tns/ac/yr	Overland erosion
Sediment Yield	0.142	tns/ac/yr	Sediment deposited in streams
Sediment Load	0.0646	tns/ac/yr	Sediment that moves through stream reaches
Nitrogen Load	6.579	lbs/ac/yr	Nitrogen moving through reaches
Phosphorus Load	30.014	lbs/ac/yr	Phosphorus moving through reaches
Organic Carbon Load	8.903	lbs/ac/yr	Organic carbon moving through reaches
Water Load/Runoff	13.935	inches/ac/yr	Amount of water running off cells into the stream reaches

Table 6. The AnnAGNPS modeling results for the Bayou Serpent Watershed are “average annual” runoff of materials over a 30 yr simulation period.

ArcView and AnnAGNPS Interface

The developers of AnnAGNPS have created a Geographic Information System (GIS)/ ArcView interface that helps extract, store, and organize input data as well as manipulate and display model outputs. The ArcView feature helps manipulate spatial and tabular data, extract spatial input parameters, develop analysis scenarios, and visualize input and output data in spatial, tabular, and graphical forms. It is a powerful graphical user interface and facilitates efficient and informed decision-making concerning agricultural non-point pollution control and watershed management. The results from the AnnAGNPS model run for the Bayou Serpent watershed are displayed in illustrations on the following pages.

Land-Use

Land-use is the most significant factor in determining the amount of runoff coming from a cell. Agricultural practices that result in the exposure of bare soil to precipitation events clearly result in greater runoff amounts than land where the surface soils have a healthy vegetative cover and root systems. Forested and pasture areas generally have lower loading rates than agricultural fields with multiple annual tillage practices.

Length-steepness Factor (LS-Factor)

AnnAGNPS generates LS factors for each cell. The LS factor may be thought of as the slope of the land. It is a physical factor that may explain why an area is losing soil and nutrients. LS factors are utilized as part of the RUSLE soil erosion equation.

The LS factors were generated by the model to determine areas that have the greatest potential for soil erosion. The slopes (LS factors) tend to be greatest near the bayou and tributaries. The model indicates that riparian areas help prevent soil loss into waterways. Maintenance of a riparian corridor has the added bonus of keeping stream temperatures lower because of all the shade trees. Waters with lower temperatures will generally have higher levels of DO.

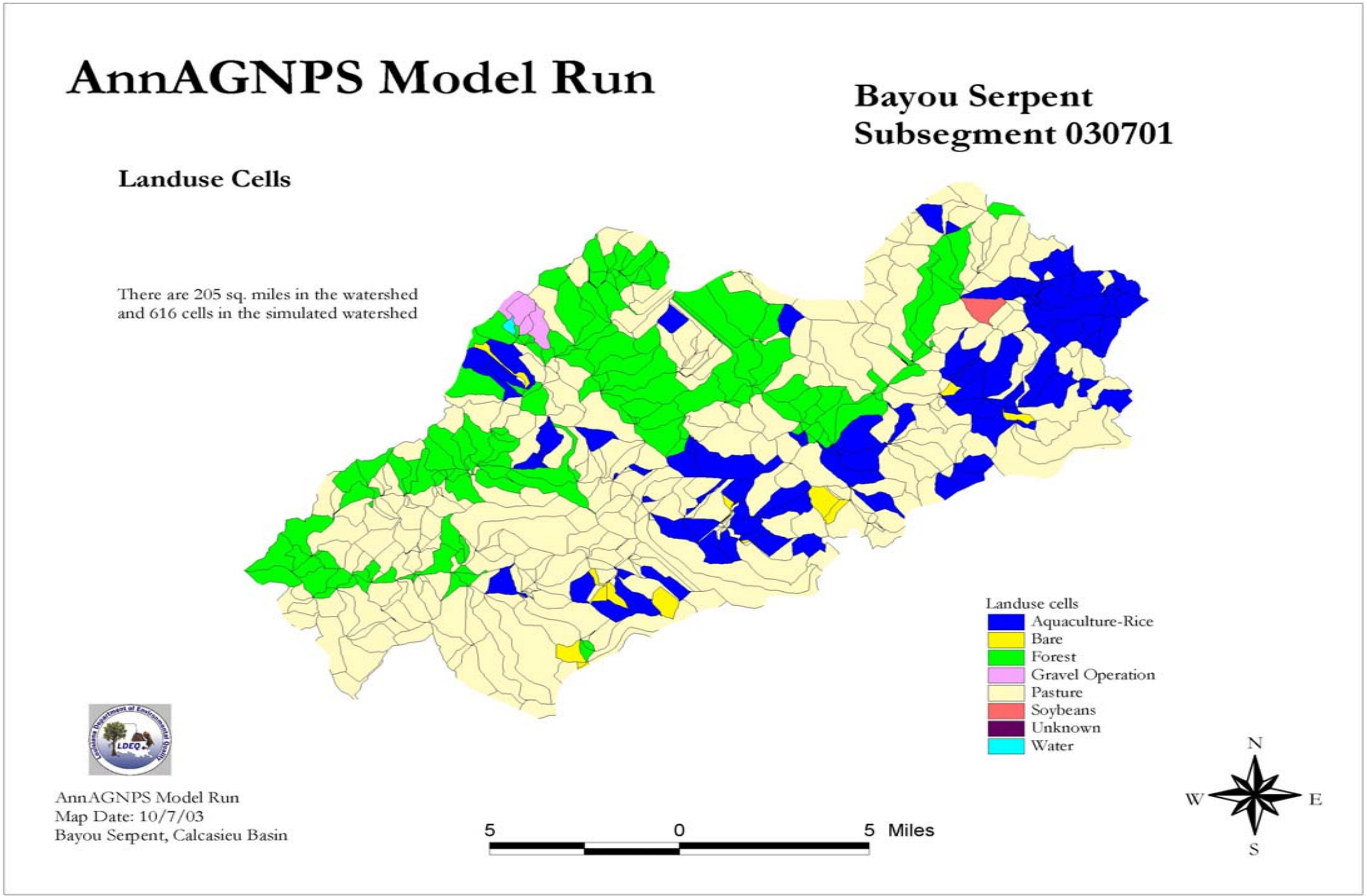

AnnAGNPS Model Run
Bayou Serpent
Subsegment 030701
Landuse Cells
There are 205 sq. miles in the watershed
and 616 cells in the simulated watershed
Landuse cells
Aquaculture-Rice
Bare
Forest
Gravel Operation
Pasture
Soybeans
Unknown
Water
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin
5
0
5 Miles

Figure 15

Soil Erodibility/K-Factor

Soil Erodibility is a soil property that is defined as the ease with which soil is detached by a splash of rainfall or surface flow or both. Physically, soil erodibility is the change in the soil per unit of applied external force or energy, namely rainfall or overland flow. Soil erodibility factor (K) in RUSLE accounts for the influence of soil properties on soil loss during storm events. It is related to the integrated effects of rainfall, runoff, and infiltration on soil loss. Physical, chemical and mineralogical soil properties, and their interactions, affect K values. Several erosion mechanisms are operating at the same time and it is unlikely that any one soil property will accurately describe K values for each soil.

Sediment Run-Off

Sediment run off is principally related to land use, slope (LS Factor), soil erodibility (K-Factor), and rainfall intensity. These variables are the most significant factors affecting agricultural NPS pollution.

AnnAGNPS estimates three general types of soil erosion: sheet, rill and gully. Sheet erosion is removed more or less uniformly from every part of the cell. Rill and gully erosion create small or large ravines by undermining and downward cutting of soils. Gully erosion may be thought of as larger and more pronounced rill erosion. Gullies eventually produce ditches or ravines, exposing subsoils to erosion.

AnnAGNPS estimates sheet, rill and gully erosion for each cell. The results found on the following pages indicate where these activities are most likely to occur. Agricultural managers and farmers can use these maps to identify the critical areas in the watershed where BMPs should be installed. Also, certain land uses tend to produce more erosion than others.

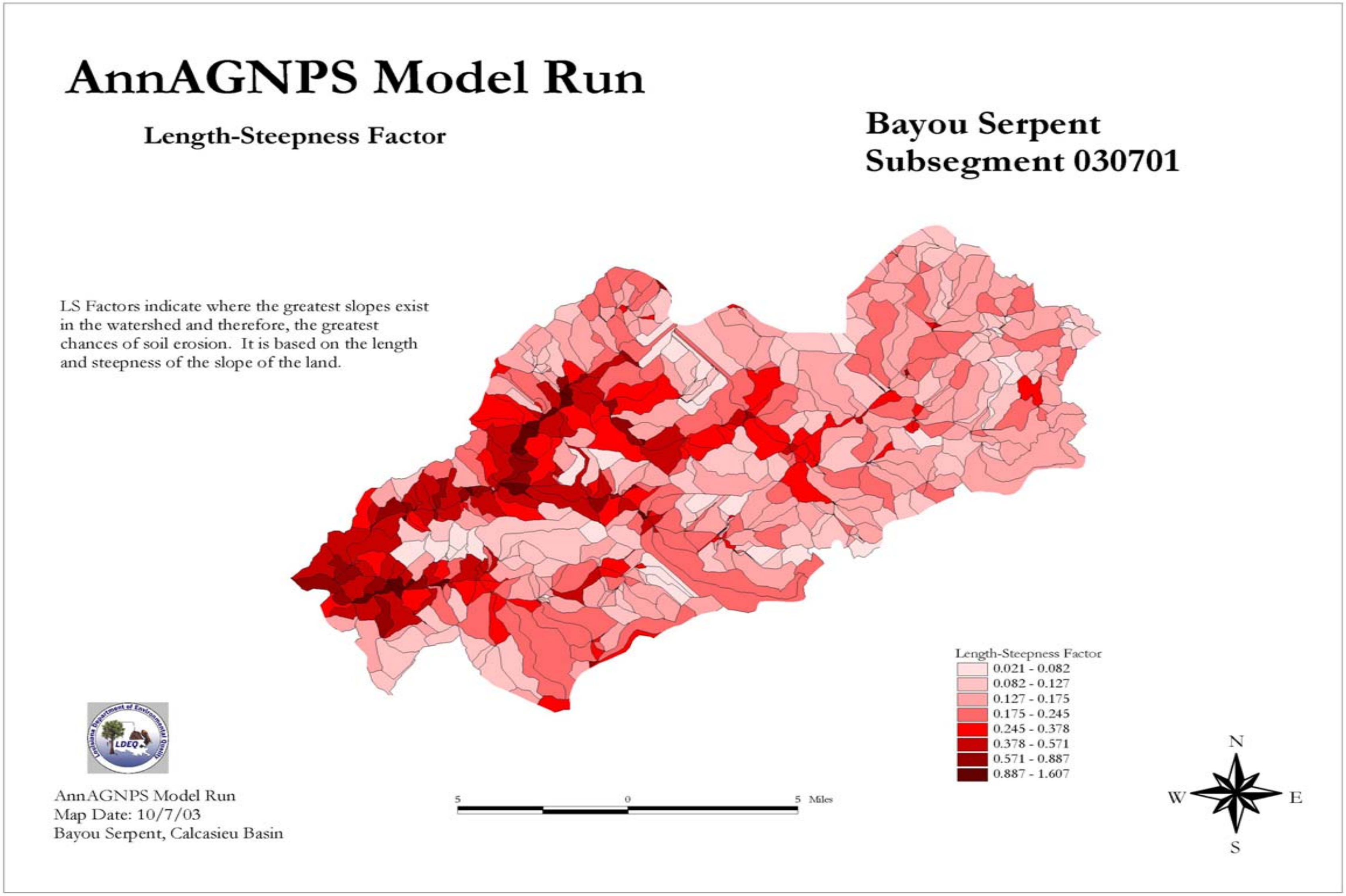

AnnAGNPS Model Run
Length-Steepness Factor
Bayou Serpent
Subsegment 030701
LS Factors indicate where the greatest slopes exist in the watershed and therefore, the greatest chances of soil erosion. It is based on the length and steepness of the slope of the land.
Length-Steepness Factor
0.021 - 0.082
0.082 - 0.127
0.127 - 0.175
0.175 - 0.245
0.245 - 0.378
0.378 - 0.571
0.571 - 0.887
0.887 - 1.607
5
0
5 Miles
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 16

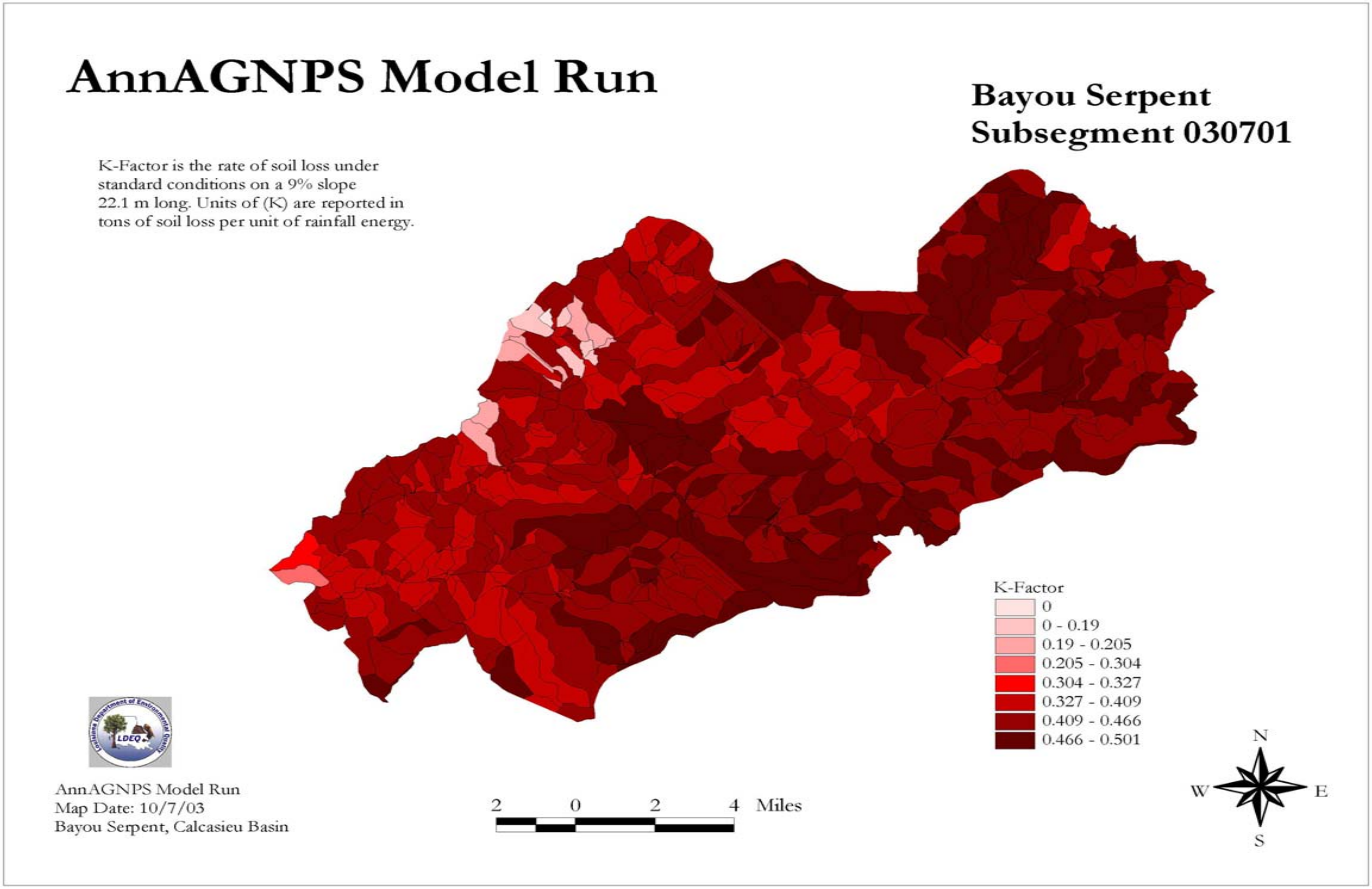

AnnAGNPS Model Run
Bayou Serpent
Subsegment 030701
K-Factor is the rate of soil loss under standard conditions on a 9% slope 22.1 m long. Units of (K) are reported in tons of soil loss per unit of rainfall energy.
K-Factor
0
0 - 0.19
0.19 - 0.205
0.205 - 0.304
0.304 - 0.327
0.327 - 0.409
0.409 - 0.466
0.466 - 0.501
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin
2
0
2
4
Miles

Figure 17

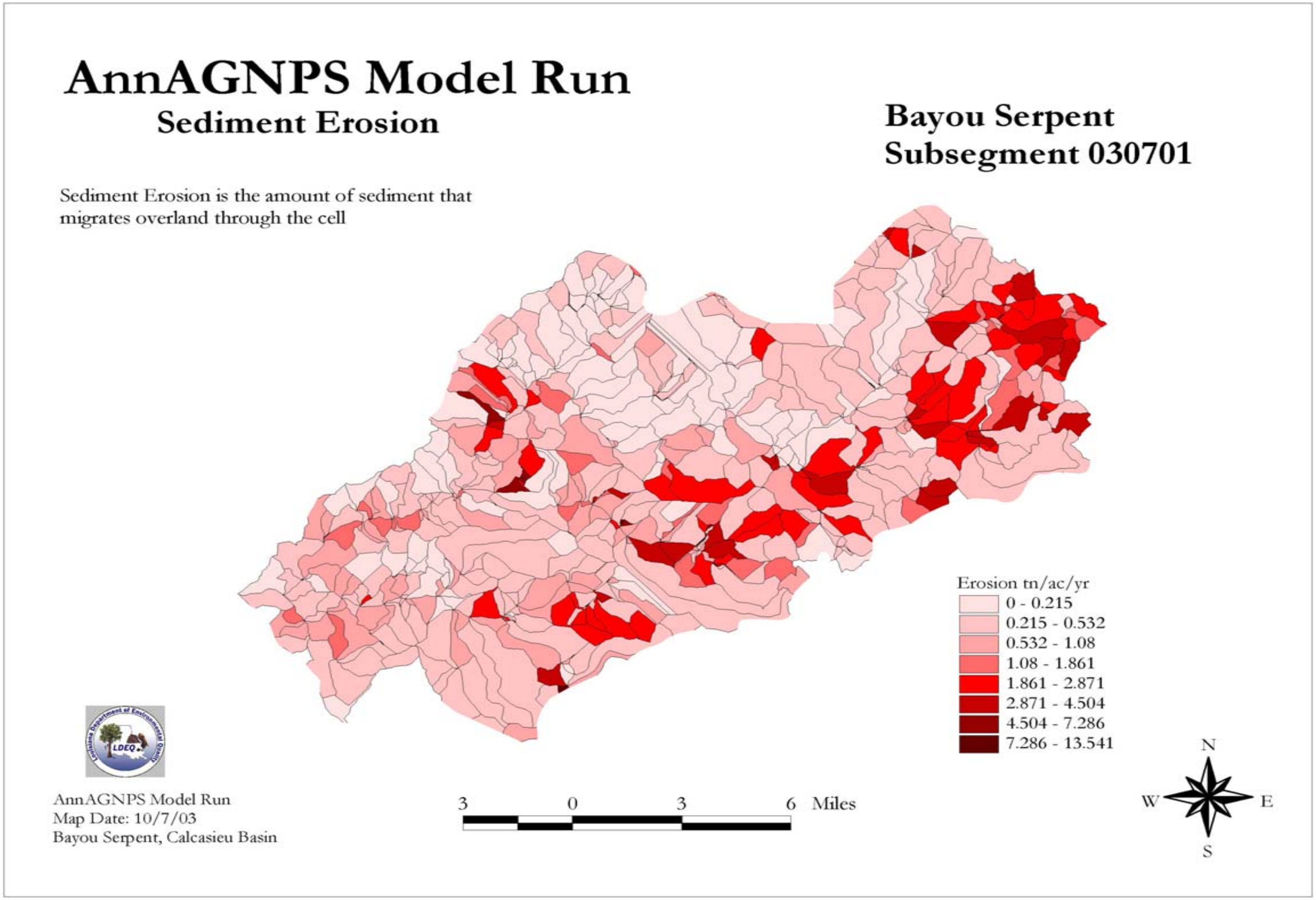

AnnAGNPS Model Run
Sediment Erosion
Bayou Serpent
Subsegment 030701
Sediment Erosion is the amount of sediment that migrates overland through the cell
Erosion tn/ac/yr
0 - 0.215
0.215 - 0.532
0.532 - 1.08
1.08 - 1.861
1.861 - 2.871
2.871 - 4.504
4.504 - 7.286
7.286 - 13.541
3 0 3 6 Miles
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 18

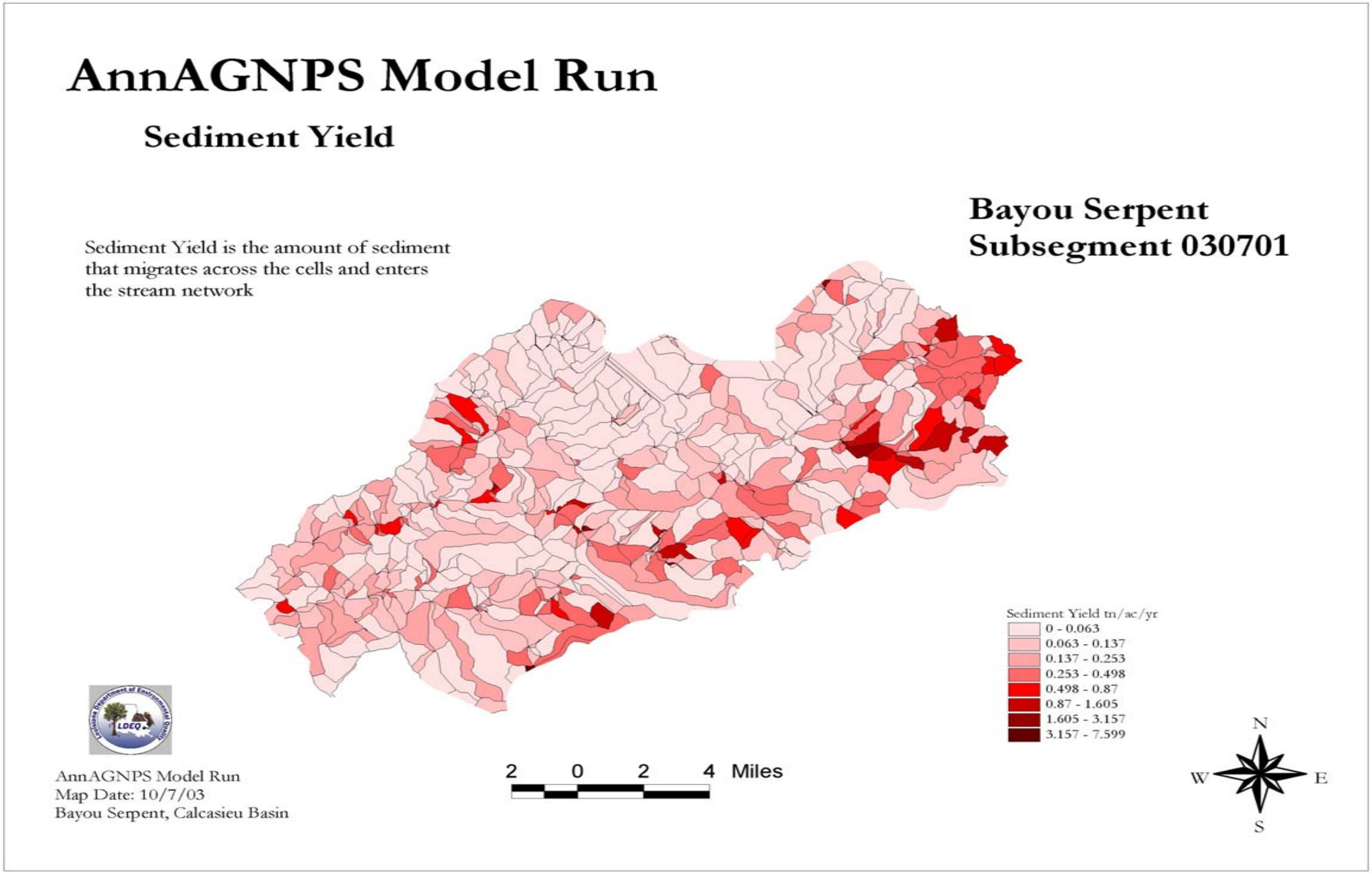

AnnAGNPS Model Run
Sediment Yield
Bayou Serpent
Subsegment 030701
Sediment Yield is the amount of sediment that migrates across the cells and enters the stream network
Sediment Yield tn/ac/yr
0 - 0.063
0.063 - 0.137
0.137 - 0.253
0.253 - 0.498
0.498 - 0.87
0.87 - 1.605
1.605 - 3.157
3.157 - 7.599
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin
2 0 2 4 Miles
N
W
E
S

Figure 19

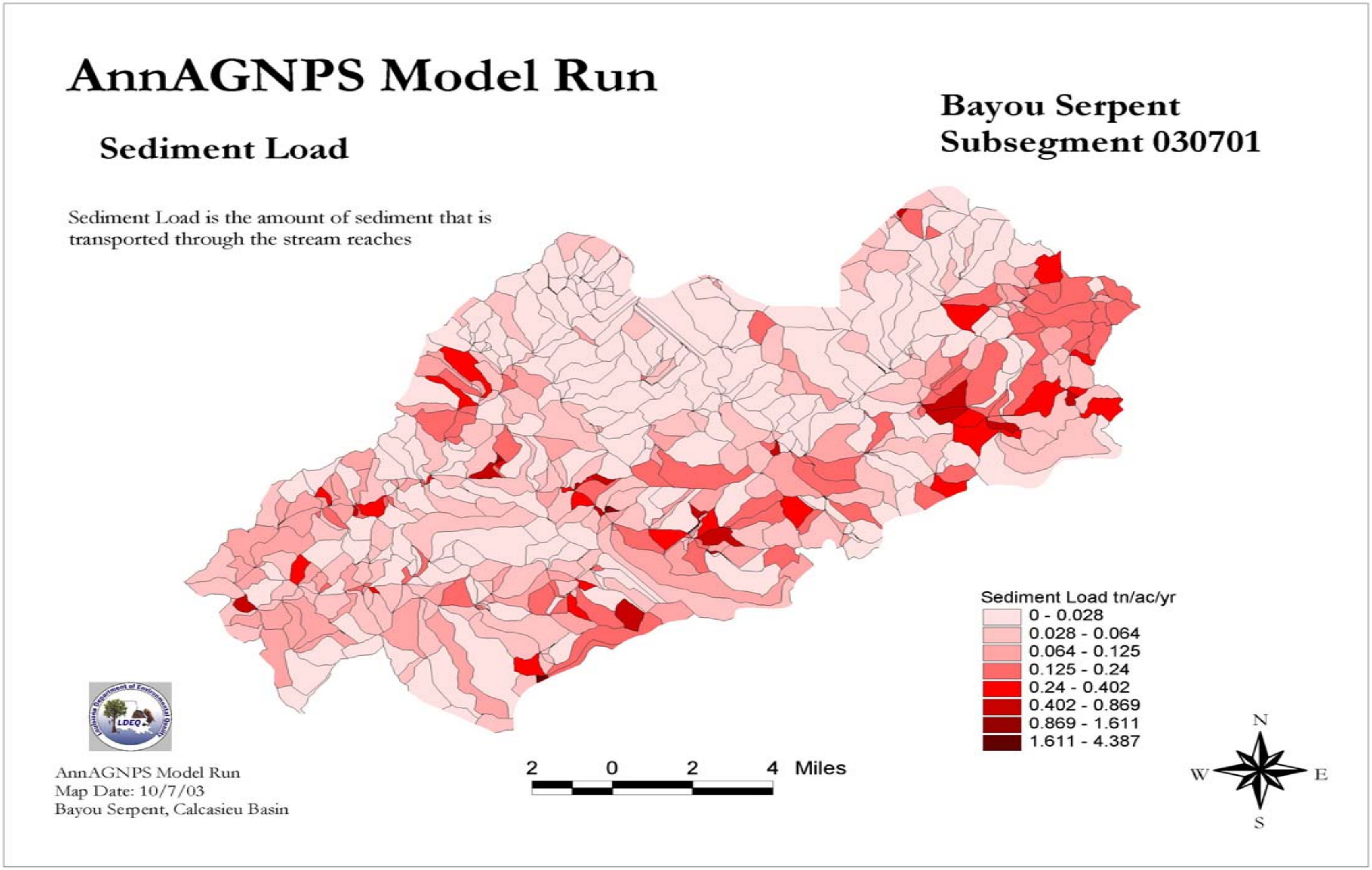

AnnAGNPS Model Run
Sediment Load
Bayou Serpent
Subsegment 030701
Sediment Load is the amount of sediment that is transported through the stream reaches
Sediment Load tn/ac/yr
0 - 0.028
0.028 - 0.064
0.064 - 0.125
0.125 - 0.24
0.24 - 0.402
0.402 - 0.869
0.869 - 1.611
1.611 - 4.387
2 0 2 4 Miles
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 20

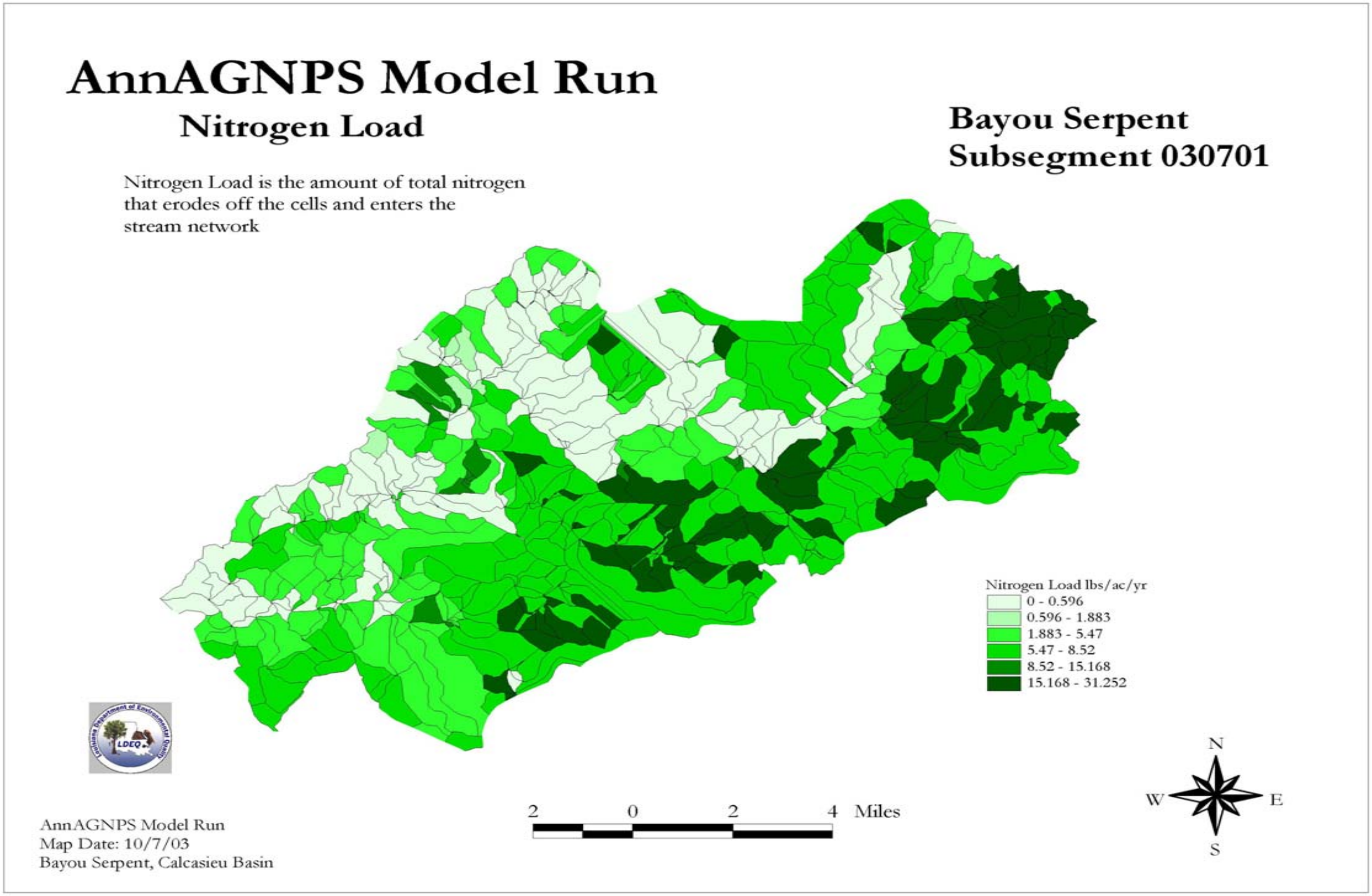

AnnAGNPS Model Run
Nitrogen Load
Bayou Serpent
Subsegment 030701
Nitrogen Load is the amount of total nitrogen that erodes off the cells and enters the stream network
Nitrogen Load lbs/ac/yr
0 - 0.596
0.596 - 1.883
1.883 - 5.47
5.47 - 8.52
8.52 - 15.168
15.168 - 31.252
2 0 2 4 Miles
N
W
E
S
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 21

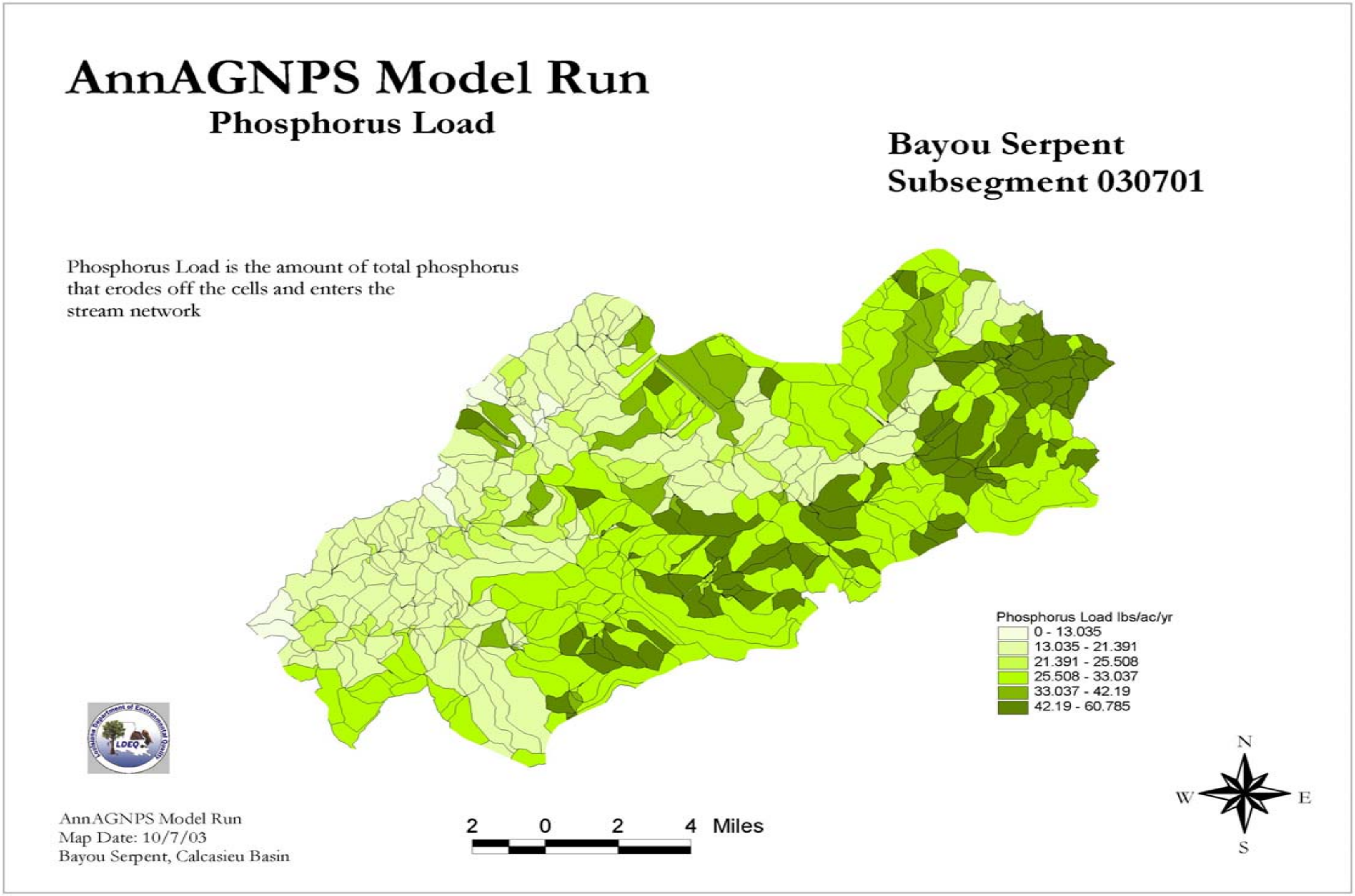

AnnAGNPS Model Run
Phosphorus Load
Bayou Serpent
Subsegment 030701
Phosphorus Load is the amount of total phosphorus that erodes off the cells and enters the stream network
Phosphorus Load lbs/ac/yr
0 - 13.035
13.035 - 21.391
21.391 - 25.508
25.508 - 33.037
33.037 - 42.19
42.19 - 60.785
N
W
E
S
2 0 2 4 Miles
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 22

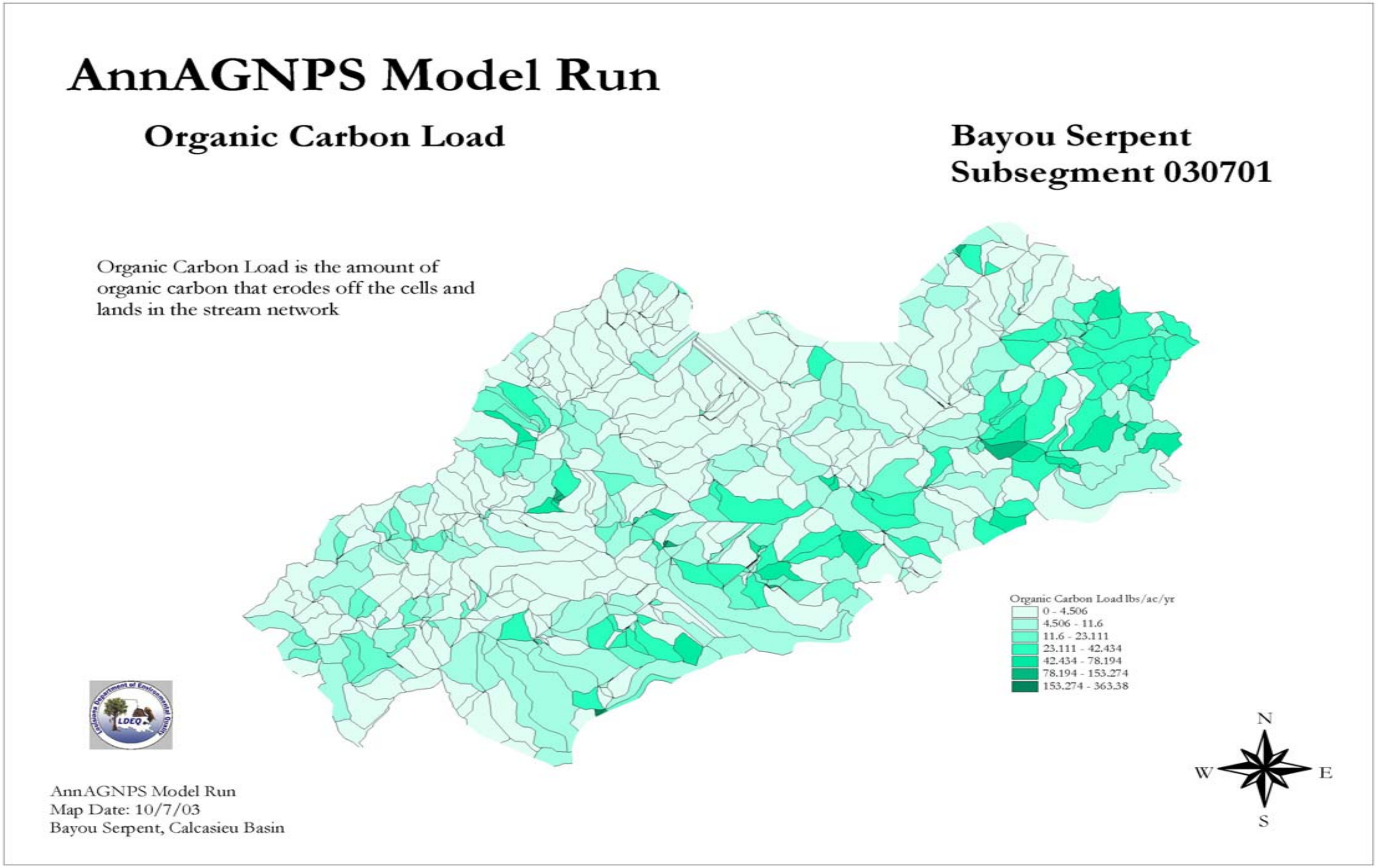

AnnAGNPS Model Run
Organic Carbon Load
Bayou Serpent
Subsegment 030701
Organic Carbon Load is the amount of organic carbon that erodes off the cells and lands in the stream network
Organic Carbon Load lbs/ac/yr
0 - 4.506
4.506 - 11.6
11.6 - 23.111
23.111 - 42.434
42.434 - 78.194
78.194 - 153.274
153.274 - 363.38
N
W
E
S
LDEQ
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin

Figure 23

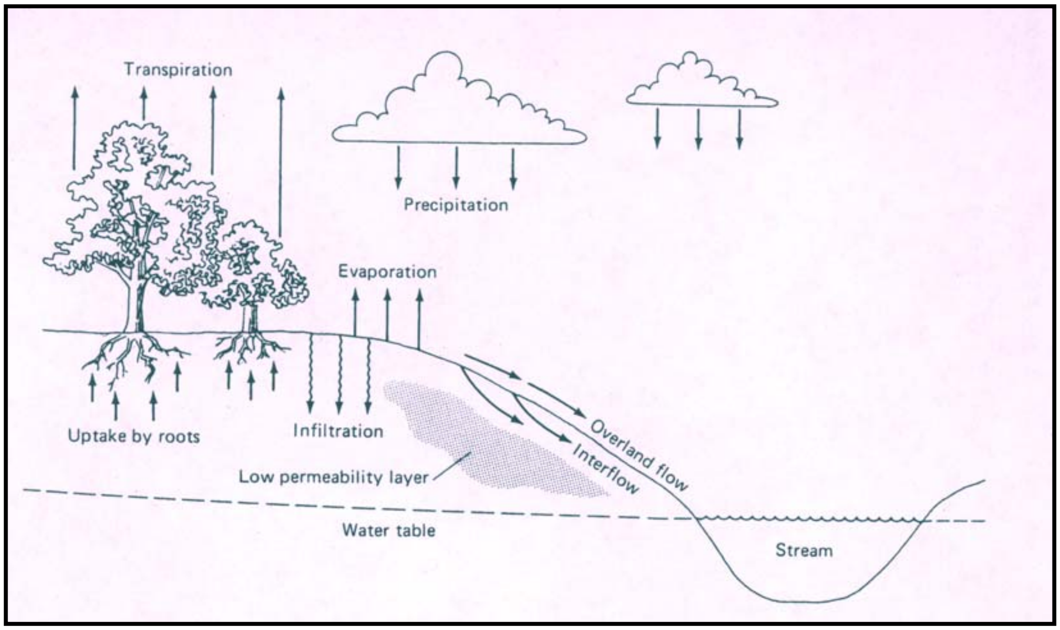


Figure 24. The figure above illustrates the hydrologic cycle. When rain falls on land, the water can follow several pathways. Some of the water will remain attached to vegetation and soil and soon evaporate after rainfall. Some of it is taken up by the roots of the plants and is evaporated through the leaves, a process called transpiration. Some of the rainfall will infiltrate into the soil where it migrates laterally toward a stream, a process called interflow. The water will also infiltrate into a permanent groundwater system. During heavy rainfall event, water will migrate overland to local waterbodies. Illustration and text provided by Drever, J.I. 1997.

Water Run-Off

The average annual rainfall in the Bayou Serpent watershed is 56 inches a year. AnnAGNPS estimates the average annual amount of water (in/acre/yr) running off of the cells. As you can see on the following illustration, water runoff varies considerably. Water runoff is influenced by a number of factors including soil permeability, presence of impermeable surfaces, slope of the land, type of vegetative cover and root mass, climate, and the chemical properties of the soil.

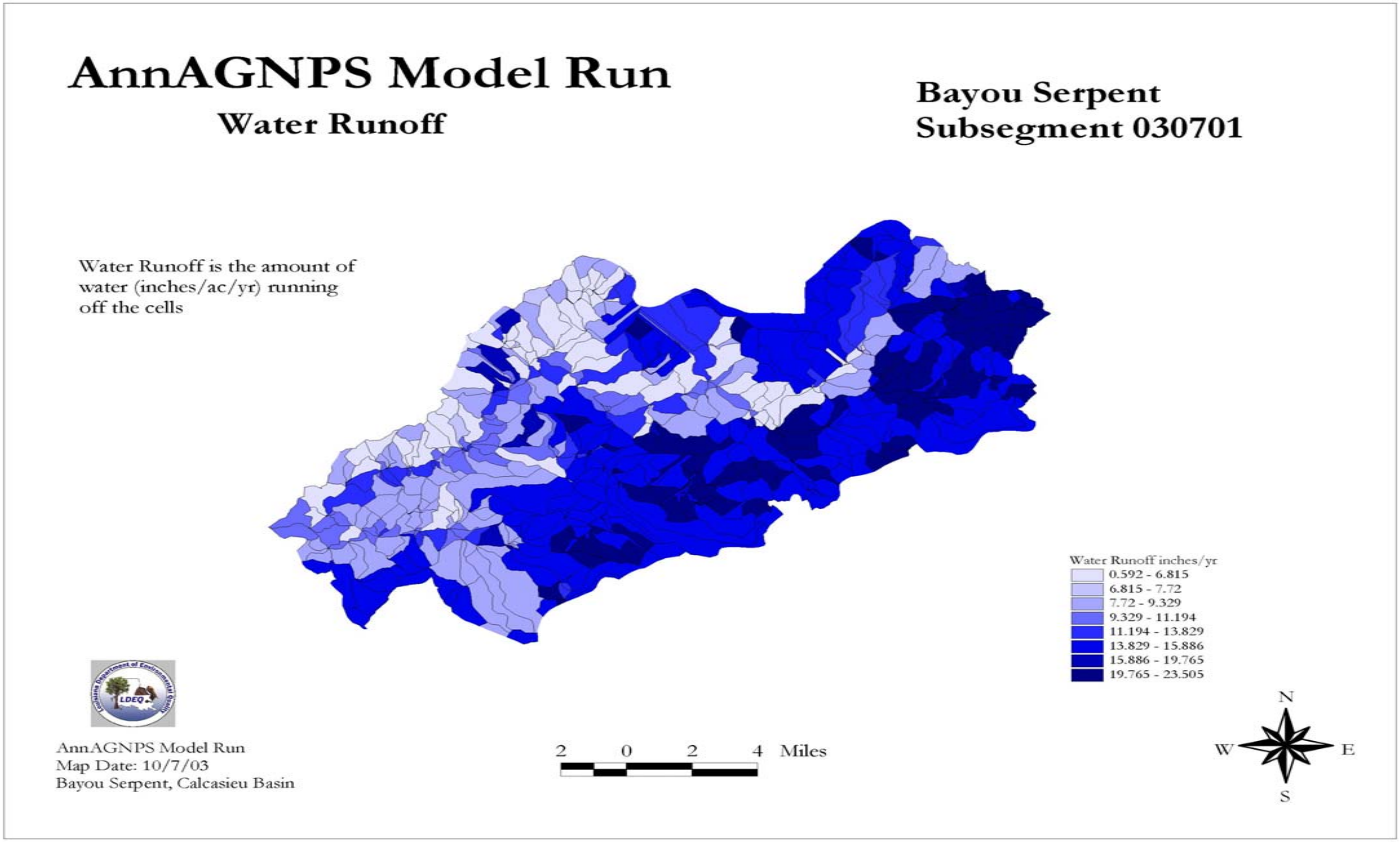

AnnAGNPS Model Run
Water Runoff
Bayou Serpent
Subsegment 030701
Water Runoff is the amount of water (inches/ac/yr) running off the cells
Water Runoff inches/yr
0.592 - 6.815
6.815 - 7.72
7.72 - 9.329
9.329 - 11.194
11.194 - 13.829
13.829 - 15.886
15.886 - 19.765
19.765 - 23.505
AnnAGNPS Model Run
Map Date: 10/7/03
Bayou Serpent, Calcasieu Basin
2 0 2 4 Miles
N
W
E
S

Figure 25

Forested Areas/Riparian Areas

Riparian or forest cell areas along the bayou had the lowest loading rates. This supports previous findings that riparian areas are effective management measures for reducing agricultural NPS pollutant loadings

Pasture

As can be seen from the Arcview representation of model results, those areas of pasture do appear to have more moderate loading rates than the aquaculture-rice and other agricultural areas. (The loading rates are not, however, as low as those for the forested areas.) Where pasture is grown, the soil is not tilled and exposed to rain events. The presence of dense root matter and vegetative cover prevents the soils from moving off the field and into the stream reaches.

4.1 Pesticides (Fipronil)

Bayou Serpent is the one segment in the Calcasieu River Basin that has been identified as impaired due to the pesticide, Fipronil. The subsegment was found to be "partially supporting" its designated use of fish and wildlife propagation because of this pesticide. The suspected source is tail water releases from rice farming operations.

A TMDL was developed by the USEPA for Fipronil. Although this insecticide has proven effective in controlling the rice weevil, crawfish production has declined since it came into use in 1999. The relationship between crawfish toxicity and Fipronil is still under study. Although strict causality has not been determined, anecdotal evidence supports the possibility that Fipronil is detrimental to the crawfish harvest.

The only known source of Fipronil in the Calcasieu River Basin is its use in rice farming. In Louisiana, the growing season ranges from mid March through September. In wet planting, water is used to flood the fields prior to planting (late February until early June). Shortly after flooding, the seed is water planted. After germination, the water is drained and the field is flooded again. The field water is then held until two weeks prior to harvest (mid July through September, depending upon when the rice was planted) when it is released. It is believed that this practice of wet planting contributes the greatest loads of Fipronil to the system.

4.2 Turbidity

Sediment is a major pollutant generated by all types of land use activities. This material can settle over large areas, where it blankets the stream bottom, and/or may become resuspended in the water column. Turbidity increases and water organisms are affected. Sediment particles may harbor harmful bacteria, pathogens, pesticides and metals. These pollutants may be redistributed as the sediment is transported. As sediments resuspend, these materials can reenter the water column and become an uncontrolled source of pollutants. The problem can be a very severe one. Sediments may also harbor microbes that deplete the water of D.O.

5.0 Agriculture

Agriculture is the dominant land use in the area (over 75%). It is a primary contributor of nonpoint source pollution. The potential long-term effects of agricultural pollutants include high concentrations of nitrogen, phosphorus, sediments, turbidity, and pesticides in water bodies. Common agricultural practices such as fertilizer application and soil tillage may increase sediments and pollutants in runoff.

The numbers in the table below are estimates of the number of acres devoted to each type of agriculture within the Bayou Serpent watershed. Land use is dynamic and therefore these numbers may vary each year.

Land Use	Acres
Pasture – Idle - Hay	64,216
Aquaculture - Rice	28,505
Forest	27,617
Bare	7,793
Soybeans	1,502
Water	625
Gravel Operation	530
Sugarcane	336
Urban	186
Shrub-Scrub	117
TOTALS	131,427

Table 7. Agricultural Land Use

Rice planting has been associated with large and turbid discharges into local waterways. Much soil may be lost from rice fields when the irrigation waters are drained. Rice may be planted in a dry seedbed or in water. In both types of planting methods, BMPs can be utilized to reduce runoff and associated pollutants. Separate BMPs exist for wet-seeded and dry-seeded fields.

5.1 Forestry

About 12 % of the land in the Bayou Serpent watershed is forested and some of this area is being farmed commercially. Silviculture is also one of the suspected causes of nonpoint source pollution.

The cultivation, harvest, and transport of lumber may have detrimental effects upon a waterbody. These include problems with organic enrichment/low D.O. and suspended solids, as cited on the 1999 §303(d) List.

The main effect of silviculture is erosion. In areas of heavy logging, concentrations of sediment and suspended solids typically increase in water bodies. Pesticides, herbicides, and fertilizers also run off and accumulate in the water body, often adhering to the suspended solid particles. Organic matter and woody debris may clog the streambed, slowing flow rates. Stream temperatures increase as overhanging trees are removed from stream banks. Without forestry BMPs, it becomes more likely that there will be an increase in nutrient enrichment and a decline in dissolved oxygen.

Road building is a big part of silviculture operations and may pose a threat to forested watersheds, especially fish habitat. Road cuts, ditches and shoulders generate stream sediment, which may smother streambeds. Stream crossings and culverts can block fish from moving up and down stream. Roads may also introduce fuel, pesticides, and other toxins into streams as well as accelerate erosion.

Extra caution should be used when harvesting timber from along the riparian corridor. The vegetation found within this streamside management zone serves as a natural filter for the water body. Specific BMPs are recommended so that the streamside management zone is not compromised during harvest activities.

Recommended BMPs include the use of portable bridges for temporary stream crossings. This will have less impact on the waterway than the full-blown construction of a permanent structure. The temporary bridge crossings should be completely dismantled and removed after the harvest is complete.

Trees should not be removed from banks or steep slopes if such removal will destabilize soil and degrade water. It is frequently the root systems of trees and large shrubs that anchor and secure the sides of the waterway while preventing erosion. Harvesting should also be limited during wet periods when forested wetlands are more sensitive to impact.

5.2 Hydromodification

Hydrologic modifications are those activities that are designed to alter the natural stream flow. Modifications include dredging, bank stabilization, locks and dams, levees, spillways, channel alignments, and in-stream construction. These activities may be conducted for purposes of navigation or flood control. All hydrologic modification has the potential to cause water quality problems.

Bayou Serpent has been heavily dredged and has numerous weirs. Much of the waterbody is used as a conveyance for agricultural and stormwater runoff. It is also a source of irrigation water.

Actions recommended by LDEQ to mitigate the negative effects of hydromodification are found in Louisiana's Nonpoint Source Management Plan, Volume 6 (2000). These include:

- Work with USDA to host a workshop on Stream Corridor Restoration;
- Develop partnerships with local drainage boards, police juries and conservation districts to implement these restoration strategies within watersheds that have been impaired by stream bank and channel alteration;
- Track the implementation rate of these methods through Local Soil and Water Conservation Districts, NRCS, and other local entities;
- Measure water quality improvement through improved habitat, biological communities, and chemistry of the water in areas where the restoration techniques have been implemented; and
- Utilize the federal, state and local regulations, laws and ordinances that are applicable to requiring that BMPs be incorporated in to 404 and 401 projects, so that the impact of hydromodification on the state's water bodies might be reduced.

6.0 Nonpoint Source Management Plan

The 303(d) Lists provide information on which water bodies are impaired or not in full support of their designated uses. Those listed, impaired water bodies are then scheduled for TMDL development. Water bodies can be delisted, or removed from the 303(d) list, because new data indicate that the water body is meeting its designated uses *or* because the TMDL has been developed.

The 305(b) Report is a summary of the water quality status for each of the water bodies throughout the state. A water body remains on the 305(b) Assessment as impaired even after the TMDL has been developed. The impairment status of a water body only changes if the water quality data indicate an improvement (or decline) in water quality.

Specific guidelines laid out in Louisiana's Nonpoint Source Management Plan, Volume 6 (2000) include:

• Continue existing demonstration projects and educational programs that address short-term nonpoint source water problems in the Calcasieu River Basin;

• Work with federal, state and local partners to plan the management strategies that should be implemented to reduce these pollutant loads;

• Determine whether additional steps are needed to reduce nonpoint source pollution from each of the land-use categories identified as contributing to loss of designated uses; and

• Continue to implement management strategies and monitor their effectiveness until water quality standards are met and designated uses are restored.

It is the objective of LDEQ to reduce the nonpoint source pollutant loads that are calculated for the Calcasieu River Basin. The goal is water quality improvement and restoration of designated uses. The 5-year basin cyclic water quality-monitoring program combined with local watershed monitoring programs will be the basis for tracking reduced pollutant loading.

The Louisiana Department of Agriculture and Forestry is presently working with LDEQ on a project in the Calcasieu River Basin, primarily in Jefferson Davis Parish. Three watersheds are included in this study: Bayou Serpent, English Bayou and Marsh Bayou. In this study, best management practices (BMPs) are being implemented on agricultural lands. Cost-share funds and technical assistance will be provided to project participants. An educational program will be developed to reach other producers in the project area. Two field days will be held to demonstrate the potential for reducing stream loadings from agricultural activities via BMP implementation. Specific practices are shown in Table 8 on the following page. The overall goal is to reduce stream loadings and improve water quality in these three bayous.

The BMPs listed in Table 8 will be implemented as part of a comprehensive BMP Plan with the benefit of cost-share payments, incentive payments, and in-kind services. The cost of implementing those BMPs not covered by federal cost-share assistance will be borne by the individual project participant and will provide part of the non-federal match funds.

BMPs	**Cost-Share/ Incentive Payments**	**Cost per acre/ Cost per structure**	**Number**	**Acres**
Conservation Crop Rotation "Dry Seeding"	0 % 100 %	$ 5 $ 10[1]		13,000 2,000
Forest Site Preparation	60 %	$ 20 per acre[2]		80
Grade Stabilization Structure	60 %	$ 650 per structure	40	
Irrigation Land Leveling	50 %	$ 200 per acre		3,850
Irrigation Water Management	100 %	$ 6 per acre[1]		9,500
Nutrient Management	0 %	$ 5 per acre		13,000
Pest Management	0 %	$ 5 per acre		13,000
Record Keeping	100 %	$ 0.50 per acre[1]		13,000
Residue Management No-Till	100 %	$ 15 per acre[1]		50
Residue Management Mulch-Till	100 %	$ 10 per acre[1]		1,790
Residue Management Seasonal	100 %	$ 5 per acre[1]		9,500
Shallow Water MGT for Wildlife	0 %	$ 5 per acre		3,000
Tree/Shrub Establishment	60 %	$ 80 per acre[2]		80

[1] 100 % federal funds for two years / 100 % Match for 3rd year
[2] For land use conversion (from cropland or pastureland)

Table 8. BMP Cost-Share Rates and Estimated Participation

Timeline for Watershed Implementation

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mermentau																			
Vermilion																			
Calcasieu																			
Ouachita																			
Barataria																			
Terrebonne																			
Pontchartrain																			
Pearl																			
Red																			
Sabine																			
Mississippi																			
Atchafalaya																			

1- Dark Grey = Collect Water Quality Data to Develop the Total Maximum Daily Loads (TMDLs)
2- Turquoise = Develop the Total Maximum Daily Load for the Watersheds on the 303(d) list
3- Green = Develop Nonpoint Watershed Restoration Action Strategies
4- Yellow = Implement Nonpoint Watershed Restoration Action Strategies
5- Light Grey = Determine Whether Actions Have Been Successful in Restoring Designated Uses
6- Blue = Develop and Implement Additional Corrective Actions Necessary to Restore Designated Uses to the Water Body

Table 9. Timeline for Watershed Implementation

7.0 Ambient water Quality Data

(http://www.deq.state.la.us/surveillance/wqdata/wqdata.aspx)

Bayou Serpent southeast of Hecker, Louisiana

DATE	TIME	DEPTH meters	FIELD PH	WATER TEMP (C)	D.O. mg/l	FIELD COND. umhos	SECCHI DISK inches	SALIN-ITY ppt
12/22/99	1030	1.0	7.21	9.26	9.25	148.0	4.0	.
11/17/99	1020	1.0	7.11	15.65	2.73	912.0	8.0	.4
10/20/99	1010	1.0	7.07	20.77	1.81	381.0	6.0	.1
09/22/99	1020	1.0	6.90	24.54	1.08	181.0	6.0	.
08/18/99	1030	1.0	7.21	29.67	2.72	181.0	8.0	.
07/21/99	0955	1.0	6.98	28.47	4.33	129.0	6.0	.
06/16/99	1010	1.0	6.89	27.38	1.61	160.0	4.0	.
05/19/99	1045	1.0	7.06	25.42	.68	219.0	6.0	.1
04/21/99	1010	1.0	6.79	20.28	.22	296.0	1.0	.1
03/17/99	0955	1.0	6.33	13.61	8.40	80.0	2.0	.
02/18/99	1040	1.0	7.02	14.67	5.97	139.0	2.0	.
01/20/99	1000	1.0	6.53	13.69	6.82	87.0	6.0	.

Bayou Serpent southeast of Hecker, Louisiana

DATE	TIME	FECAL COLIFORM MPN/100ML	TOTAL COLIFORM MPN/100ML
------	----	---------	---------
12/22/99	1030	500	.
11/17/99	1020	30	.
10/20/99	1010	30	.
09/22/99	1020	50	.
08/18/99	1030	50	.
07/21/99	0955	30	.
06/16/99	1010	30	.
05/19/99	1045	2	.
04/21/99	1010	50	.
03/17/99	0955	30	.
01/20/99	1000	50	.

Bayou Serpent southeast of Hecker, Louisiana

DATE	TIME	DEPTH meters	ARSENIC ug/l	CADMIUM ug/l	CHROMIUM ug/l	COPPER ug/l	MERCURY ug/l	LEAD ug/l	NICKEL ug/l
------	------	------	-------	-------	--------	------	-------	-------	-------
12/22/99	1030	1.0	.	.	.	.	.	.	.
11/17/99	1020	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
10/20/99	1010	1.0	.	.	.	.	.	.	.
09/22/99	1020	1.0	.	.	.	.	.	.	.
08/18/99	1030	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
07/21/99	0955	1.0	.	.	.	.	.	.	.
06/16/99	1010	1.0	.	.	.	.	.	.	.
05/19/99	1045	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
04/21/99	1010	1.0	.	.	.	.	.	.	.
03/17/99	0955	1.0	.	.	.	.	.	.	.
02/18/99	1040	1.0	K 5.00	K .50	K 2.50	K 2.50	K .0500	K 5.00	K 5.00
01/20/99	1000	1.0	.	.	.	.	.	.	.

Bayou Serpent southeast of Hecker, Louisiana

DATE	TIME	DEPTH meters	NO2+NO3 mg/l	T.K.N. mg/l	PHOS. TOTAL mg/l	T.O.C. mg/l
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12/22/99	1030	1.0	.590	1.41	.28	12.60
11/17/99	1020	1.0	.110	1.06	.21	12.10
10/20/99	1010	1.0	.210	1.17	.20	11.40
09/22/99	1020	1.0	.310	1.35	.38	9.90
08/18/99	1030	1.0	.060	1.32	.19	7.70
07/21/99	0955	1.0	.160	1.48	.24	5.88
06/16/99	1010	1.0	.290	1.56	.26	9.90
05/19/99	1045	1.0	.450	2.21	.20	12.40
04/21/99	1010	1.0	.900	9.59	1.89	29.90
03/17/99	0955	1.0	.110	2.23	.33	10.90
02/18/99	1040	1.0	.500	2.71	.50	12.10
01/20/99	1000	1.0	.130	1.65	.21	8.00

Bayou Serpent southeast of Hecker, Louisiana

DATE	TIME	DEPTH meters	ALKA-LINITY mg/l	HARD-NESS mg/l	TURB-IDITY NTU	COLOR PT-CO units	CHLOR-IDES mg/l	SULFATE mg/l	T.S.S. mg/l	T.D.S. mg/l
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12/22/99	1030	1.0	24.6	22.8	90.0	110.0	20.6	7.5	57.6	155.0
11/17/99	1020	1.0	40.7	94.1	13.0	100.0	236.0	30.5	15.0	530.0
10/20/99	1010	1.0	35.4	44.2	33.0	110.0	77.8	11.6	18.0	280.0
09/22/99	1020	1.0	41.9	33.7	30.0	110.0	24.6	6.2	11.0	168.0
08/18/99	1030	1.0	35.3	30.7	27.4	110.0	29.3	4.4	16.0	138.0
07/21/99	0955	1.0	31.7	26.0	60.0	100.0	17.8	2.7	29.0	144.0
06/16/99	1010	1.0	39.4	30.7	102.0	70.0	24.9	4.0	47.0	201.9
05/19/99	1045	1.0	50.8	42.6	95.0	60.0	32.2	8.7	7.5	251.9
04/21/99	1010	1.0	59.7	K 5.0	1600.0	80.0	45.1	8.6	129.0	1728.0
03/17/99	0955	1.0	15.8	21.4	310.0	80.0	10.8	4.6	121.0	482.0
02/18/99	1040	1.0	27.8	33.6	250.0	50.0	17.5	5.7	170.0	242.0
01/20/99	1000	1.0	17.0	14.8	130.0	60.0	10.5	3.5	49.0	176.0